

THE SPATIAL AWARENESS COMPETENCE

of

TASMANIAN INFANT and PRIMARY TEACHERS and STUDENT TEACHERS

by

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ABSTRACT

A two-component model of teacher Spatial Awareness competence, a spatial abilities component and a 'syllabus-specific' component, was used as the basis for this study. The two samples tested were a 1-in-10 random sample of Tasmanian Infant and Primary teachers (via postal survey) and the year IV (i.e. last year of teacher training) Tasmanian Infant and Primary student teachers. The response rates were, respectively, 79.1% (178 out of 225) and 84.3% (193 out of 229). For each teacher and student teacher two tests were completed, a spatial abilities test and one of two parallel forms of an original Spatial Awareness Teaching Test (SATT). The latter was a 36 item test based on the Kindergarten to Grade 6 range of the Spatial Awareness strand of the (Tasmanian) Primary Mathematics Guidelines. It was noted that other tests of teacher and student teacher geometry on space competence had apparently not contained the range of classroom relevant test items for the grade range of responsibility of their samples. However, in the present study in keeping with the Guidelines, SATT was divided into three subtests, the Infant, Middle Primary, and Upper Primary subtests, formed from consecutive groups of 12 questions, respectively. To simplify reporting and analysis the data from both forms of SATT were combined into a single SATT. The combined data were analysed at two levels. First, a description of SATT results and item competences for the two samples was given. As well,

a description of subtest results and item competence for the teacher subsample at their main level of teaching (Infant, Middle Primary or Upper Primary) and student teachers at their level of teacher training (Infant or Primary) was given. In addition, the errors of teachers and student teachers on the most difficult items from their relevant subtest were tabulated and briefly discussed.

At the second level of analysis, SATT score for both samples was adjusted for the spatial abilities component (thus making the 'residual' SATT score more 'syllabus-specific') and then analysed with various factors. For teachers, the four out of nine factors which were initially found to be significant were used in a four-way stepdown ANCOVA. 'Secondary mathematics background', 'level of teaching', 'feedback' were significant and 'sex' became non-significant. The in-service implications of these results (based on this order of significant factors) were discussed. For student teachers, as all their four factors were initially found to be significant, a four-way stepdown ANCOVA was performed. 'Secondary mathematics background' and 'course of study' remained significant and 'feedback' and 'sex' became non-significant. The implications of these results for entry into teacher training, pre-service mathematics education and inservice mathematics education were discussed. Suggestions for further study based on the ideas of the present study were made.

STATEMENT OF ORIGINALITY

This thesis contains no material which has been submitted for examination in any other course or accepted for the award of any other degree or diploma in any university and, to the best of my knowledge and belief, contains no material previously published or written by another person except when due reference is made in the text.

Signed: *K. C. Anderson*

K.C. Anderson

Date: *4/11/83*

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DEDICATION

This study is dedicated to those teachers who, often in spite of onerous professional and domestic demands, participated in the trial testing and main survey.

There is not a single one of the questions I have touched upon in this account of education and teaching since 1935 that does not connect, sooner or later, with that of teacher training. The most admirable of reforms cannot but fall short in practice if teachers of sufficient quality are not available in sufficient quantity.

Piaget, 1970

... whether much more of this kind of thinking (spatial visualisation) could be introduced into teaching in many fields if teachers had more ability, or training in this area. Again, we are referring to the fact that teachers, being largely selected on the basis of their own ability in the verbal factor, are likely to restrict their handling of any subject to the abilities in which they themselves excell. X

T.G. Thurstone, 1957



## CHAPTER 1

## THE STUDY OF TEACHER AND STUDENT TEACHER COMPETENCE

1.1 Introduction

In this chapter the purpose of the study is outlined. Next, the definition of some of the common terms in the study <sup>S</sup> is given. In section 1.3 the importance of teachers in education is discussed. After brief mention of teacher attribute studies, Hook's criterion of 'intellectual competence' is used to discuss those studies dealing with Infant and Primary teacher competence or achievement or knowledge with the material they teach.

Section 1.5, on the study of teacher and student teacher mathematical competence, serves as an introduction to Section 1.6, a review of the relevant literature. The review especially notes several deficiencies. In Section 1.7 the potential importance of spatial abilities for the present study is mentioned and a review is made of the literature on teacher spatial ability.

The review of the more specialized literature is in Chapter 2. In Section 2.2 a review of studies into Infant and Primary teacher geometry or space competence is given and some deficiencies noted. Section 2.3 deals with studies that have explored relationships between spatial abilities and mathematical abilities. A synthesis of these 2 sections is made in Section 2.4 and questions about teachers and their

abilities in geometry/space are posed.

### 1.2 The Purpose of the Study

The research reported here has two main components. The first component is a description of the competence of Tasmanian Infant and Primary teachers and student teachers with the Spatial Awareness strand of their mathematics syllabus, the (Tasmanian) Primary Mathematics Guidelines. This competence is looked at two ways; first, with the complete strand, which covers Kindergarten to Grade 6 (K-6), and second with that part corresponding to their main level of teaching interest, Infant (K-2), Middle Primary (3-4) or Upper Primary (5-6).

The second component is an examination of the relationships between that competence and the other variables in the study, e.g. sex, age, secondary mathematics background, level of teaching, and spatial abilities.

The first component, that of describing the competence of teachers and student teachers with the Spatial Awareness material they teach, appears to be such a potentially useful exercise that it is perhaps surprising that so little in this area seems to have been done. While teacher knowledge is only one component of an often complex interplay determining the quality of teaching and learning, it nevertheless seems reasonable to isolate and investigate this component.

The second component, that of the elucidation and explanation of this competence through consideration of some

of the other variables of this study, while of possibly less immediate practical importance than the first component, is nevertheless of potential theoretical importance. There may, for example, be important relationships between competence in spatial abilities and Spatial Awareness. For instance secondary mathematics background may be a significant predictor of syllabus competence. Further, there may be significant relationships to sex, age, or type of teacher training.

### 1.3 Some Definitions

#### 1.3.1 'Spatial Awareness'

This thesis contains an investigation of a part of the mathematical competence of Tasmanian teachers and student teachers; the strand of the mathematics syllabus dealing with 'space'. This strand has the name 'Spatial Awareness'. Other authors and education systems have called similar content areas variously, space, spatial relations, geometry, informal geometry, and pre-geometry. Whenever the term Spatial Awareness occurs in this study it means the Tasmanian version of the space/geometry syllabus. It is reproduced in Appendix A.

#### 1.3.2 'Spatial Abilities'

The term 'spatial abilities' is considered to be the ability or abilities to form mental images of (usually) simple shapes or patterns, with or without manipulation. It is here considered as an ability dependent on neither specialized

knowledge, (e.g. geometry, technical drawing or mechanics) nor training (Clements, 1978; Guay, 1980).

### 1.3.3 'Syllabus'

The term 'syllabus' means a statement, often in some detail, of the contents of a course of study.

### 1.3.4 'Mathematics'

'Mathematics' is the umbrella term which in its widest sense encompasses, among others, the topics of arithmetic or number, geometry or space or spatial relations, measurement (from the point of view of number manipulation), sets, algebra, calculus and logical relations. Each of these strands can be thought of as being separate from each other historically, epistemologically, and pedagogically. Obviously if one is talking about mathematics in the Infant school, for example, one may be talking of just 2 or 3 of these topics, but in this thesis it is never used as a synonym for just one of the aforementioned topics.

### 1.3.5 'Infant'

By 'Infant' is meant the grades Kindergarten to Grade 2 (K-2). In these grades children are usually aged approximately 4 to 7 years old.

### 1.3.6 'Middle Primary'

By 'Middle Primary' is meant Grades 3 and 4 (3-4). In these grades children are aged approximately 8 to 10 years old.

### 1.3.7 'Upper Primary'

By 'Upper Primary' is meant Grades 5 and 6 (5-6). In

these grades children are aged approximately 11 to 12 years old.

#### 1.3.8 'Primary'

'Primary' means 'Middle Primary' and 'Upper Primary' combined, that is, Grades 3 to 6 (3-6).

### 1.4 The Study of Teacher and Student Teacher Competence

#### with the Material of their Curriculum

A first assumption underlying this project is that of Sidney Hook's concerning the intellectual competence of teachers:

By this I mean ... the truism that the teacher should have a mastery of the subject matter he is teaching and that he should keep abreast of important developments in his field ... (Hook, 1965)

The reasonableness of Hook's criterion of 'intellectual competence' and the accompanying explanation can hardly be doubted. For whatever else education is, it is certainly concerned with knowledge and with skills which use knowledge. However, it seems that little is known about teacher and student teacher 'intellectual competence' with the subject matter they teach. For example, Dunkin and Biddle in their well known The Study of Teaching (1974) quoted not a single study which specifically included teacher knowledge or abilities with the material they taught. Only a few studies of indirect relevance were quoted; for instance Bruce (1971), which dealt with the attitudes and questioning styles of 33

recently trained teachers in Elementary school science, and another (Wilson, 1969) which compared the questioning styles of 15 teachers also recently trained in science to 15 'traditional' teachers. In both studies teacher competence with science knowledge was either assumed adequate or not considered pertinent enough to warrant examination. This would seem typical of the vast majority of similar teacher effectiveness and teacher attitudinal studies.

Some explanation for this seeming neglect of research into teachers' knowledge of their teaching area or areas may lie in the assumption that this is one of the fulfilled aims of teacher training. But how reasonable is this assumption? Dettrick (1978), for instance, showed with a Victorian sample of mainly Secondary mathematics teachers ( $N=40$ ) that serious deficiencies existed in their abilities with conservation tasks on length, area and volume.

With Australian Infant and Primary teachers the assumption of a minimum knowledge competence with their curriculum must be open to at least partial doubt if only because of the extent of the curriculum. It is at least very difficult to be familiar with so many fields of knowledge - mathematics, science, music, physical education, reading, social studies and literature - even at the elementary levels necessary for most Infant and Primary pupils.

1.5 The Study of Teacher and Student Teacher  
Mathematical  
Competence

A second assumption of this study is that mathematics and Spatial Awareness have a proper place in the school curriculum, especially in the Infant and Primary school (Griffiths and Howson, 1976). While it is not the purpose here to justify this assumption, or indeed the first assumption of Hook's 'intellectual competence', it still seems necessary to explicitly state it. That is, if we accept that mathematics is a proper part of the school curriculum then it is appropriate that teacher mathematical competence be examined.

The problem of teacher mathematical competence could be approached in a manner analagous to that of pupils. Just as society might expect of its pupils a certain mathematical competence at each grade level, age, or cognitive stage (e.g. the statement by the Joint Mathematical Council of the U.K., Basic Mathematical Skills - Curricula and Assessment, 1977), minimum mathematical criteria might also be established for teachers to reach and maintain. Such, however might not, in practical terms, be an easy task. Changes in mathematics syllabi have left many older and experienced teachers unsure or unfamiliar with the new content. Many Infant and Primary teachers possibly have an inadequate mathematical background because they often drop mathematics when it becomes optional in the later years of High School. Few Infant and Primary teachers take elective mathematics at their teacher training

institution. And, the course structure favoured by many Infant and Primary teachers, that of degree and end-on Diploma of Education, can mean a break from formal mathematical thinking of four, five or six years. The knowledge competence of Infant and Primary teachers in mathematics would seem a topic not only worthy but necessary of investigation.

#### 1.6 A Review of the Literature on Infant and Primary Teacher Mathematical Competence

What follows is a country by country survey. This approach, rather than the usual chronological one, has been adopted because of the different educational history and milieu of each country.

First, in the U.K. there have been two studies, Lumb (1974) and Rees (1974). Lumb tested 400 student teachers twice, first at entry to their teacher training institution and at 18 months later. In summary he wrote:

The depths of ignorance of mathematical facts and basic computational skills revealed in the initial test were staggering ... 76% of the students could not place five simple fractions in order of size ... The performances in the final test were better but still left a lot to be desired. ... 58% still could not place the five fractions in order of size ...

He concluded:

Students who are having difficulty understanding mathematics cannot be expected to make good teachers of mathematics and the lack of good mathematical teaching will not produce children who either like, or are successful in, the subject. Consequently, there is a vicious circle perpetuating the problem.

It seems that the test was basically computational with a sprinkling of questions on (undefined) modern mathematics. As



the questions were taken from Schools Mathematics Project Books 1 and 2 they would have been of a standard suitable for children aged 11 to 13. The number of questions which related to topics from the Infant and Primary range was not stated. Neither was the number of intending Infant teachers in the sample.

Rees (1974) tested 108 Primary student teachers at the end of their second year at a College of Education. By that time all had completed a college mathematics course. On a 50 item test they scored a mean of 31.7 with a standard deviation of 8.5. However, little information on the questions was given so their relevance to Infant and Primary mathematics curricula is difficult to establish.

In Australia it seems that the only comprehensive survey of inservice teacher mathematical competence has been that by Dettrick (1981). The entire Infant and Primary teacher population of an administrative region in Victoria was surveyed using 1 of 3 randomly assigned Basic Mathematics Competencies Test<sup>s</sup> (BMCT). A total of 117 test items were distributed across the major topic areas of the Primary curriculum, for example, Measurement, Pattern and Order, Operations, Place Value, Spatial Relations, Fractions, Processes, Money, and Statistics and Graphs. The response rate was 82% of the teacher population, and the mean score was 68.4% with a standard deviation of 14.7%. X

Dettrick's discussion of the results is worth quoting extensively.

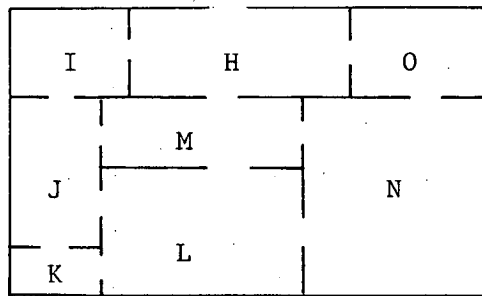
... the average achievement on the BMCT forms was 68 percent. This was considerably below the 80 percent competency level which was regarded as reasonable for the test. An 80 percent result is almost one standard deviation above the mean obtained. The sub-test results showed that overall performance was best for Operations, Fractions, and Processes although none of these produced results consistently above the competency level set, and then performance declined in two further steps, though Measurement, Money, and Statistics and Graphs, and finally to Spatial Relations, Place Value, and Pattern and Order. The results for individual items indicated teachers obtained an 80 percent or better correct response rate to 48 (41%) of the 117 test items. A count of items with facility indexes less than .50 and less than .60 produced 21 items (18%) and 38 items (32%) respectively out of the total of 117 items.

In assessing the import of Dettrick's study, two initial comments can be made. First, it would appear that the questions used may have been weighted toward the Upper Primary grades. Indeed, there were some which were perhaps not suitable at all for Primary pupils. Consider, for example, BMCT Form 1, q. 11 (see Fig. 1.1). The relevance of this question to Infant and Primary mathematics could be questioned. It is obviously a topological question but it is not one which would appear to have any special relevance except after a treatment of networks and traversability. There are other, more suitable and shorter questions which could have been asked. It was, nevertheless, answered correctly by 64% of the 130 who attempted it.

Figure 1.1

Question 11, BMCT I from Dettrick (1981)

11. This diagram represents the plan of a art gallery with only one entrance. Arthur, a frequent visitor, wondered if it would be possible to walk through every internal doorway exactly once, starting in the entrance hall, H.



Arthur would find that:

- A it is possible and he finishes at the entrance hall.
- B it is possible but he always finishes in room N.
- C it is possible but he finishes in different rooms, depending on his route.
- D it is impossible to do.

Second, the grade responsibilities of teachers should be taken into account. That is, teacher mathematical competence should be related to the demands of the particular teaching situation and the material they actually teach. For example, how can the knowledge competence of a Grade 2 or 3 teacher with the beginnings of multiplication be inferred from a knowledge of their performance on the question (BMCT, Form 1, q. 39)?:

What is the product of 9.74 and 4.26?

It can be argued then that Dettrick's 80% mastery level may have been unrealistic given the diversity of teacher responsibility in his sample. This mastery level is perhaps only realistic for a subsample of teachers on tasks relevant to their teaching level. Perhaps it is only Upper Primary teachers who should know the complete Kindergarten to Grade 6 mathematics syllabus.

Given the nature of the questions and the diversity of teacher responsibility in the sample the 68% average achievement found was probably not a bad result. Possibly some relevant teaching deficiencies were uncovered. And by concentrating on Upper Primary teachers some reasonable inferences as to the quality of the teacher knowledge component in mathematics teaching could be made.

Notwithstanding, these comments on Dettrick's (1981) study should be seen as only minimally detracting from its worth. The survey is an important contribution to the understanding of Primary and Infant teacher mathematical

competence. It was probably the first comprehensive survey in Australia. Its results will undoubtedly serve as much food for thought for Infant and Primary inservice and pre-service mathematics teachers, at least in Victoria.

Student teacher surveys of mathematical competence in Australia have been numerous but not comprehensive. Anderson (1981) surveyed Australian teacher training institutions and collated most of the published and unpublished material. In spite of the limited data the survey pointed to the continuing problem of large numbers of almost innumerate student teachers. The limitations of the data sprang from the use of a large number of different, locally produced and nonstandardised tests used by institutions with incoming students for mostly numeracy diagnostic purposes.

One of the most comprehensive surveys of student teachers in Australia was that by Squire (1979). Students were tested at the beginning of their teacher training course and again at the end of their first year. The test consisted of 50 items, 5 each covering the topic areas arithmetic, decimals and bases, the metric system, sets, properties of number, algebra, problem solving, informal geometry, statistics, and probability. Table 1.1 gives a breakdown of pre- and post-test results by topic area. Overall means were 63.5% for the pre-test and 83.3% for the post-test, a gain of 19.8%.

Table 1.1

A Summary of Data from Squire (1979)

(Percentages of the whole sample in each skills area with less than 4 out of 5 items correct on pre- and post-tests.)

Skills Area	Pretest % N = 243	Posttest % N = 188
1. Computational Arithmetic	39.5	8.0
2. Decimals and Bases	75.3	31.4
3. Metric System	39.1	7.4
4. Set Theory	69.5	23.4
5. Properties of Number	95.9	52.1
6. Algebra	45.7	22.3
7. Problem Solving	45.7	11.7
8. Informal Geometry	69.2	25.0
9. Statistics	94.6	45.7
10. Probability	53.5	13.3

### Commented Squire:

It can be claimed that the diagnosis and remediation was successful but at the same time there are many aspects of the program open for improvement. While the mean score on the post-test was over 80% (our target), two areas in particular were still not handled successfully by about 50% of students even after the skills program. Greater attention needs to be given to these two topics, Properties of number and Statistics.

The number, if any, of Infant student teachers in the sample was not stated. However, since the test was published it is possible to ascertain its curricular relevance over the Kindergarten to Grade 6 range. Typically, it would seem biased towards the Upper Primary.

Only a few surveys in Australia have used standardised tests. The ACER Teacher's College Test was used by ACER (1955). The authors found "... more than half of the students in primary teachers' college ... revealed some weakness in mathematics."

In the U.S. the question of Elementary (i.e. in Australian terms Infant and Primary) teacher mathematical competence has long been of research interest at both the inservice and pre-service levels. The findings have typically been variations on two themes; either competence was low, so low as to be the cause for concern or there was a significant gain in competence after a semester or two of this or that mathematics or mathematics education program. The studies peaked in number in the mid 1960s, dropping off markedly in the 1970s, perhaps because of the similarity of many of the findings to the earlier research and the lack of cheap, easy-to-implement solutions.

Some of the studies have been extensive in their range of mathematical topics covered. Others have been more intensive, covering just one of, for example, arithmetic, measurement or geometry. As the area of concern of this thesis is Spatial Awareness the relevant specialised studies on space/geometry are reviewed separately in the next chapter.

Although a review of all the more extensive studies is beyond the scope of this thesis it is of interest to review two studies by the same trio of authors. These studies (Gibney, Ginther and Pigge, 1970; Pigge, Gibney and Ginther, 1979) were replications covering an eight year span, and they consisted essentially of data gained from testing groups of inservice and pre-service teachers, together with a number of comparisons. The first group of inservice and pre-service teachers were tested in 1967-9, the second in 1975-7. The topics covered in the testings were geometry, number theory, numeration systems, fractions, properties of whole numbers, sets, and the four operations on whole numbers. Table 1.2 is a summary of the subtest data from both periods.

It can be seen that the pre-service teachers were significantly better than their inservice counterparts. So too were the 1975-7 sample compared with their 1967-9 counterparts. As well, the 1975-7 sample was significantly better on six of the seven topic areas; only the topic of Sets showed no significant differences.

Figure 1.2 shows mean scores for subsamples based on preferred grade level. The trend of inservice teachers to



Table 1.2

A Summary of Data from Pigge, et al. (1979).

## 1967-69 Data

Subtest	Preservice teachers (N = 887)		Inservice teachers (N = 177)		Comparison pre 67 vs in 67
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	
Geometry	5.14	1.59	4.63	1.60	*
Number Theory	5.37	2.01	4.75	2.20	*
Numeration System	4.65	1.69	4.42	1.64	
Fractional Numbers	6.15	2.26	5.83	2.22	
Structural Properties	4.41	2.19	3.69	2.23	*
Sets	3.29	1.24	3.04	1.33	*
Operations	4.36	1.72	4.27	1.77	
Total Test	33.37	8.88	30.70	8.90	*

\*  $p < .05$ 

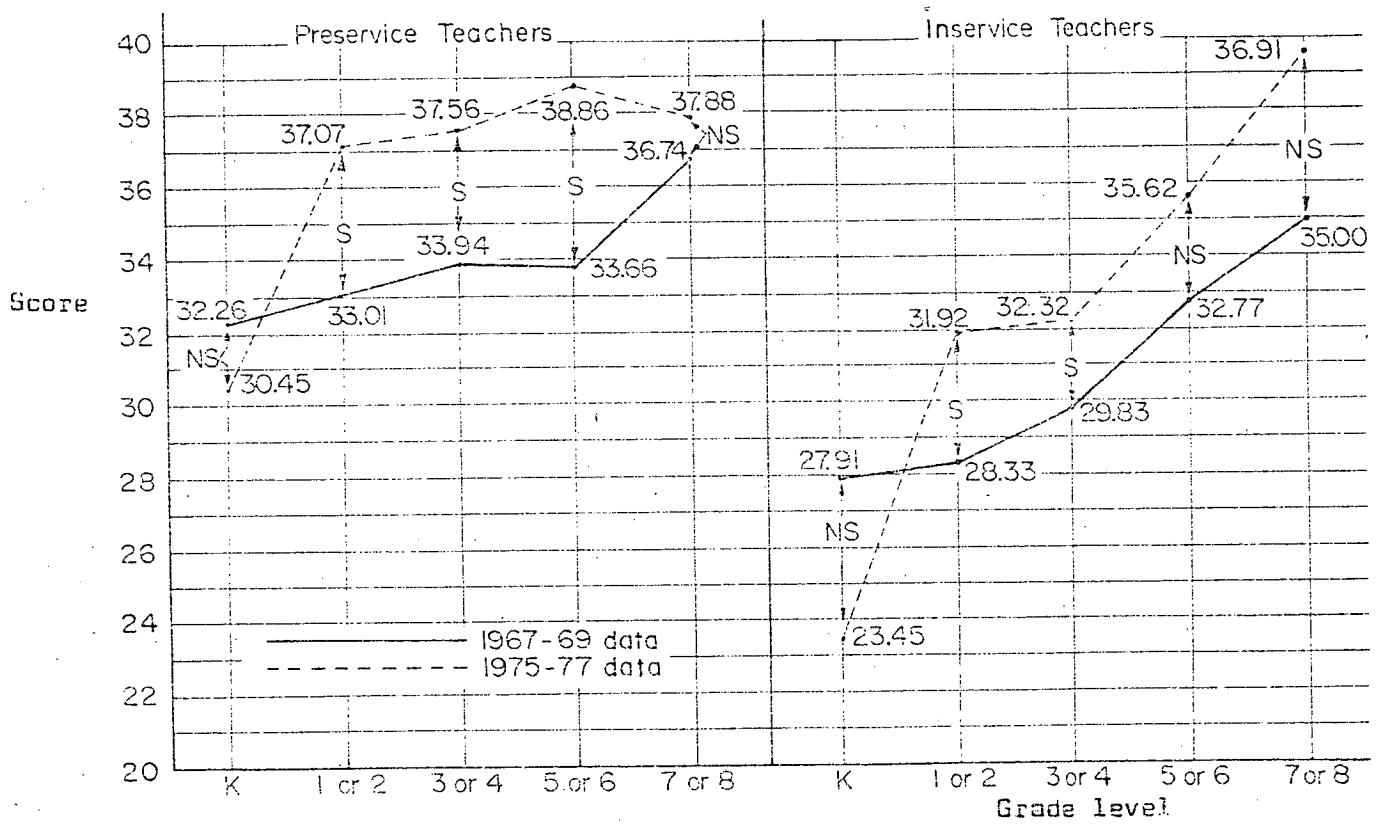
## 1975-77 Data

Subtest	Preservice teachers (N = 737)		Inservice teachers (N = 241)		Comparisons		
					pre 75 vs in 75	pre 67 vs pre 75	in 67 vs in 75
	$\bar{x}$	s.d.	$\bar{x}$	s.d.			
Geometry	6.05	2.00	4.99	2.17	*	*	*
Number Theory	6.15	2.09	5.62	2.42	*	*	*
Numeration System	5.52	1.89	4.93	2.02	*	*	*
Fractional Numbers	5.66	2.45	5.35	2.51		*	*
Structural Properties	5.77	2.74	4.33	2.85	*	*	*
Sets	3.88	1.37	3.15	1.58	*	*	
Operations	5.04	1.90	4.77	2.04		*	*
Total Test	38.07	10.97	33.13	12.16	*	*	*

\*  $p < .05$

Figure 1.2

Comparisons of Teachers in 1967-9 and 1975-7 by grade level Preference from Pigge, et al. (1979).



S, statistically significant  
NS, non-significant

score higher, the higher their grade level of responsibility, is unmistakable, though for reasons which are not self-evident. Was it that teachers who were weak mathematically tended towards teaching the lower grades? Or was it that even if teachers were mathematically comparable before their training (or before induction into teaching) that teachers in the lower grades lost some of their mathematical skills through not using them? That there was a similar trend with the pre-service teachers as well would support the former possibility, but that the pre-service trend was also less marked would fit with the later. It would seem that both might be true.

As was the case with Dettrick (1981) few of the items in these two U.S. studies appear to have been appropriate for the lower grades. The relevance of the test questions as a basis for an assessment of the mathematics competence of teachers with material at the level at which they teach was thus limited.

### 1.7 The Study of Teacher and Student Teacher Spatial Abilities

Spatial abilities have long been of interest to psychologists and educators. Indeed it could be said that some parts of the curriculum are best understood through mental images and their manipulation. Geometry, geography, and parts of science, are just some of the more obvious examples. But what of teaching and teacher spatial abilities?

It seems that there have been only three published studies of teacher or student teacher spatial abilities, Martin (1967), Eley (1977) and Battista, Wheatley and Talsma (1982).

The last of these will be discussed in Chapter Two because of its much closer relevance to the specifics of the present research. Martin (1967) assessed the spatial abilities of mathematics teachers to see if they were potentially able to fulfil the aims of many of the new geometry syllabi, many of which demanded greater spatial skills on the part of teachers than was previously the case. He tested various groups of student teachers ( $N=313$ ) and teachers ( $N=60$ ) with two standardised spatial abilities tests - the Differential Aptitude Space Relations Test (DATSR) and the Revised Minnesota Paper Form Board Test (MPFB). See Table 1.3. There were large differences in scores between subsamples. Prospective Secondary mathematics teachers had the highest mean score and prospective social science teachers the lowest. The mean of prospective Elementary teachers was slightly below sample mean.

In Table 1.4 there are comparisons of freshmen (beginning) mathematics students, experienced Elementary, and experienced Secondary mathematics teachers. The Elementary teachers were inferior in performance.

If the samples of Elementary student teachers (prospective Elementary mathematics teachers,  $N=75$ ) and Elementary teachers (experienced Elementary teachers,  $N=35$ ) are compared it can be seen that the student teachers had higher means on both tests,

Table 1.3

Data on Spatial Visualization Scores of Student Teachers from Martin (1967).

	Groups*						All Groups
	PSM	PEM	PSS	PAI	PE	PS	
Sample size	57	75	45	41	46	49	313
DATSR <sup>#</sup>							
Maximum	95	80	77	95	72	96	96
Minimum	12	5	14	13	12	5	5
$\bar{x}$	59.18	47.04	44.73	52.34	45.41	55.47	50.69
s.d.	15.79	14.75	14.40	17.27	13.29	19.69	16.69
MPFB <sup>@</sup>							
Maximum	57	57	57	60	53	62	62
Minimum	20	18	9	23	21	1	1
$\bar{x}$	43.70	40.84	39.53	43.63	39.22	43.84	41.77
s.d.	7.23	8.27	9.21	8.20	6.65	10.24	8.51

\*PSM, prospective secondary mathematics teachers; PEM, prospective elementary mathematics teachers; PSS, prospective social science teachers; PAI, prospective art/industrial arts teachers; PE, prospective English teachers; PS, prospective science teachers.

<sup>#</sup> Differential Aptitude Space Relations Test

<sup>@</sup> Revised Minnesota Paper Form Board Test

Table 1.4

Data on Spatial Visualization Scores of Freshman Mathematics Students and Experienced Teachers from Martin (1967).

	Groups*			
	FM	EEM	ESM	EEM and ESM
Sample size	157	35	25	60
DATSR <sup>#</sup>				
Maximum	96	70	84	84
Minimum	20	5	27	5
$\bar{x}$	59.89	41.17	58.60	48.43
s.d.	15.69	15.42	14.25	17.17
MPFB <sup>@</sup>				
Maximum	61	57	58	58
Minimum	28	10	33	10
$\bar{x}$	44.28	38.86	46.76	42.15
s.d.	7.00	8.82	7.06	8.97

\*FM, First-quarter freshman mathematics students;  
 EEM, experienced elementary mathematics teachers;  
 ESM, experienced secondary mathematics teachers.

<sup>#</sup> Differential Aptitude Space Relations Test

<sup>@</sup> Revised Minnesota Paper Form Board Test

but probably not significantly so (information not given in Martin's report).

However, the data of this study appear to be unrelated to its aim. Recall that its purpose was to assess the spatial abilities of teachers from the point of view of the demands of new geometry syllabi. Nowhere was there a discussion of the spatial demands of these programs or how performances on the two spatial tests related to them. The design and execution of the study was better intended to answer the other and fulfilled question, that of the relative differences between various samples of student teachers, freshmen mathematics students and teachers.

Eley's (1977) spatial abilities data were part of a larger survey which compared the verbal and spatial abilities of beginning Diploma of Education students having different degree backgrounds. For the spatial component he used three standardised spatial tests. Unfortunately summaries of test performances were not included. Nor was there information on the intended teaching level of the student teachers.

In summary, it can be said that of the little data that is known about teacher and student teacher spatial abilities little of it seems useful in revealing relationships between spatial abilities and Spatial Awareness competence.

### 1.8 Summary

In this chapter we have reviewed the literature on Infant and Primary teacher and student teacher mathematical competence. It was found that the data available were invariably based on items inappropriate for the measure of teacher and student teacher mathematical competence relevant to their professional needs. In addition, the data on teacher and student teacher spatial ability was such as to be of little use in revealing relationships between it and Spatial Awareness competence.



## CHAPTER 2

### A REVIEW OF INFANT AND PRIMARY TEACHER GEOMETRY COMPETENCE AND A REVIEW OF THE RELATIONSHIPS BETWEEN GEOMETRY COMPETENCE AND SPATIAL ABILITIES

#### 2.1 Introduction

In Section 2.2 of this chapter studies of the geometry competence of Infant and Primary teachers and student teachers are reviewed. These studies are of a number of types. There are those which have taken the study of geometry competence as their main purpose. There are those which have looked at geometry competence incidentally because their main purpose was elsewhere, such as the development of a new unit of work within geometry. And there are those comprehensive mathematics competency studies, initially reviewed in Chapter One, but which contained geometry subtests. In Section 2.3 some of the relationships between spatial abilities and mathematical, especially geometrical, competence are examined. These two sections are synthesised in Section 2.4 where some research proposals concerning teacher geometry competence and spatial abilities are posited.

#### 2.2 Studies of Infant and Primary Teacher Geometry

##### Competence

In Chapter One Hook's notion of 'intellectual competence' was used as a first assumption in arguing that we need to

assess teacher and student teacher mathematical competence, and that the basis for this assessment should be the relevant mathematics syllabus. In particular, this would suggest that teacher and student teacher geometry and space competence should be assessed relative to the geometry and space component of the mathematics syllabus taught, or intended to be taught, by that individual. Consequently, studies of teacher and student teacher geometry competence will now be reviewed. As the research reported here is mostly from the U.S., their term 'Elementary', that is Kindergarten to Grades 6, 7 or 8 inclusive, is used as a synonym for the Australian terms, Infant and Primary.

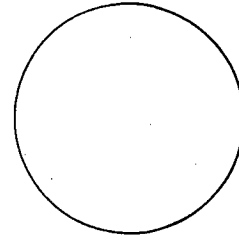
#### 2.2.1 Specialised Studies of Geometry Competence

The first published account of Elementary teacher geometry competence would seem to be that by Weaver (1966). He tested three groups of predominantly Elementary teachers (N=104) with a 12 item test on plane (i.e. two dimensional) figures. Two examples of these items are given in Figures 2.1 and 2.2. The findings indicated that teachers having the greatest exposure to recent inservice mathematics courses tended to attain higher test scores, and that teachers tended to score higher, the higher their grade level of responsibility. However, the interpretation of these findings in terms of teacher competence was confounded because all questions seemed dependent upon a working knowledge of set theory, especially the notions of inclusiveness and exclusiveness. While it could be argued that teachers in the 1960s should

Figure 2.1

Question 4 from Weaver (1966).

This is a drawing of a . . . .

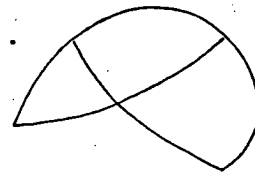


Polygon	YES	NO	NOT SURE
Quadrilateral	YES	NO	NOT SURE
Rectangle	YES	NO	NOT SURE
Simple closed curve	YES	NO	NOT SURE
Square	YES	NO	NOT SURE
Triangle	YES	NO	NOT SURE

Figure 2.2

Question 9 from Weaver (1966).

This is a drawing of a . . .



Polygon	YES	NO	NOT SURE
Quadrilateral	YES	NO	NOT SURE
Rectangle	YES	NO	NOT SURE
Simple closed curve	YES	NO	NOT SURE
Square	YES	NO	NOT SURE
Triangle	YES	NO	NOT SURE

have known sufficient set theory for them to answer the questions, such nevertheless implies that test performance was dependent upon a non-geometric factor.

Backman (1969) tested geometry understanding with 65 of the 73 Elementary (K-5) and Middle School (6-8) teachers in a small school district in the U.S. The sample was a mixture of teachers who taught across the whole curriculum, mainly Grades K-3, and others who specialised in mathematics. On an original 56 item geometry test, the average result obtained was 46%. While the test scores were not analysed by teacher grade level, an inspection of the items revealed many to be unsuitable for use at lower grades; they were mostly at a minimum Grade 7 standard. In fact the test was partly validated using Grade 9, 10 and 11 pupils.

Bailey (1969) tested Elementary education majors (N=361) who had completed the mandatory mathematics part of their pre-service training. With an original 50 item geometry test, he found that 70% of subjects scored 70% or less. Moreover, a multiple regression analysis showed that the completion of a high school geometry course and the completion of a college mathematics education course were the only measures out of six tested to significantly predict geometry test performance. Again however, while the test items were spread over the Elementary grades, only a small number would have actually been suitable for use in the lower grades.

Keith (1970) conducted an extensive postal survey of the geometry competence of Virginian Elementary (K-6) teachers.

Of the 680 teachers contacted 32.5% (N=221) responded, but because of incomplete data problems only 29.3% (N=199) were used. The test comprised 30 items based either on general geometrical concepts that the teachers should have known, as recommended by such bodies as the U.S. Committee on the Undergraduate Program in Mathematics, or on concepts and skills in textbooks commonly in use. The teachers scored a mean of 20.18 (67.3%) with a standard deviation of 5.85, and significant correlations were found with sex (male), extent of mathematics background, level of teacher training (all positive), age, and years of experience (both negative). Keith concluded that Virginian Elementary teacher knowledge of geometry seemed "... somewhat deficient in some areas."

Banning (1971) tested the geometry competence of Elementary (K-6) student teachers (N=15) using an original 30 item test, and found a mean score of 13.6 items correct. While the sample size was perhaps too small to justify Banning's conclusion that "... many Elementary teachers... have insufficient background in the geometry taught in Elementary schools", the study is of interest because of the test and its method of construction. It was based on material taken from four textbook series then in common use in schools, and the items used were quite deliberately distributed over the entire grade range. Although items based on the lower grades were perhaps underrepresented, the distribution was probably the best of all the studies cited so far.

A similar survey of the geometry competence of Elementary student teachers was conducted by Ferguson (1972). His original 65 item test was also based on material from common mathematics textbooks, but his items were all based at the Grade 5 or 6 level. With a much larger sample ( $N=189$ ) than Banning's a mean score of 31.56 (48.6%) items correct (standard deviation 15.00) was found. A multiple regression analysis showed each of completion of a high school geometry course, completion of a college geometry course, completion of a mathematics teaching methods course, years of study in college, and average high school mathematics mark to be significant predictors of test performance, whereas number of years of high school mathematics, completion of a college general mathematics course, completion of a college modern mathematics course, and number of years since last mathematics course all proved nonsignificant.

Ferguson concluded that:

... many of the prospective elementary school teachers ... are not receiving the necessary training in familiarizing them with the geometric material which they may encounter in the textbooks in use in the elementary classrooms ...

These surveys seem to be the extent of the comprehensive research projects on teacher and student teacher geometry competence. Unfortunately, the methodologies of some of them show deficiencies. As previously intimated in Chapter One, the actual or intended grade levels of responsibility of the sample were often inadequately described, and questions relevant to that actual or intended grade level were often not

provided. Further however, there sometimes appeared to be confusion with what constituted the subject matter of geometry. For example, many items dealt with measurement of area and volume, and with the graphing of number lines and number planes.

Although the studies cited in this section are a valuable contribution to the study of teacher and student teacher geometry competence there are still two aspects inadequately dealt with. It seems that usually the items do not adequately reflect the grade range of responsibility of the teacher sample. As well, only some of these studies differentiate between the grade or teaching levels of the teacher sample when reporting results.

#### 2.2.2 Other Studies of Geometry Competence

For the sake of completeness, four further studies which only tangentially examined teacher or student teacher geometry competence will now be reviewed. Gannon (1972) tested Elementary student teacher knowledge of topology and was led to conclude that topology was a subject potentially learnable by student teachers. Such would perhaps fit with findings that in the child's development of space concepts (e.g. Piaget and Inhelder (1956), Sauvy and Sauvy (1974), Laurendeau and Pinard (1970)) topological notions seem to have some degree of temporal primacy. Interestingly, Gannon also found that there was no significant difference on achievement between teachers who expressed a teaching preference for either Grades K-3 or Grades 4-6.



The second of these tangential studies was by Gates (1976). While the primary research interest was attitudinal, a geometry achievement test based on the topic of plane regions yielded no significant differences between Elementary student teachers (N=35) in either an experimental (activity) based learning group or a traditional instruction group.

The two remaining studies both dealt with learning hierarchies. Russell (1972) developed two hierarchies for concepts from non-metric geometry, the first concerned with one and two dimensional figures, and the second, superordinate to the first, concerned with the classification of polygons according to angles and numbers of sides. The Elementary student teacher subjects (N=26) were found to be unable to master the superordinate tasks until they had mastered the subordinate.

Mayberry (1983) devised a four level hierarchy representative of quality of geometry thought and argued that teachers in the upper Elementary grades would need to operate at least at Level II (Level IV being the highest). She found 52% of her student teacher sample (N=19) to be below this Level II, the level characterised by knowledge of relations and class inclusions but not of formal deductive procedures.

Despite their mostly small sample sizes, these four studies complement the picture gained from Section 2.2.1. They point to the often ill-preparedness of student teachers to teach geometry in the Infant and Primary grades.

### 2.2.3 The Geometry Subtest of the Comprehensive Mathematics Studies

A more detailed discussion will now be given of the geometry/space sections of two of the comprehensive mathematics studies mentioned in Chapter One.

Pigge et al. (1979) compared data from pre- and inservice teachers for two periods, 1967-9 and 1975-7. From Table 2.1 which summarises the geometry subtest data it can be seen that pre-service teachers would seem to have been more competent than inservice for both periods. Further, it would seem that for both pre-service and inservice separately, the later groups performed better than the earlier. Unfortunately, only one geometry item from the test was given (see Gibney et al., 1970), and thus the extent to which the test reflected the range of grade levels could not be determined. As noted in Section 1.6, the study also made competency comparisons across grade level of responsibility. However, such analysis was not extended to geometry subtest scores and it was thus not possible to view geometry competence also by grade level of responsibility.

The other comprehensive mathematical competence survey mentioned in Section 1.6 was that by Dettrick (1981). A summary of the Spatial Relations subtest data is given in Table 2.2. Dettrick's interpretation was that teachers performed poorly on these subtests. Of the nine subtests in the survey Dettrick found that Spatial Relations ranked seventh. One potential way of accounting for this relatively

Table 2.1

Geometry subtest data from Pigge, et al. (1979)  
(Maximum score = 10)

## 1967-69 Data

	Preservice teachers (N=887)		Inservice teachers (N=177)		Comparison pre 67 vs in 67
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	
Geometry	5.14	1.59	4.63	1.60	*

## 1975-77 Data

	Preservice teachers (N=737)		Inservice teachers (N=241)		Comparisons		
					pre 75 vs in 75	pre 67 vs pre 75.	in 67 vs in 75
	$\bar{x}$	s.d.	$\bar{x}$	s.d.			
Geometry	6.05	2.00	4.99	2.47	*	*	*

\*  $\underline{p} < .05$

n)

Table 2.2

Spatial Relations Subtest Data from Dettrick (1981)

BMCT	No.	N	No. of Questions	Mean Score (%)	s.d. (%)
1		130	7	50	23
2		130	9	62	19
3		128	7	64	23

poor subtest performance might be to suggest that teachers were unfamiliar with the spatial material which they were supposed to teach. Although they have always been topics in Australian Infant and Primary school mathematics syllabi, space and geometry might often have been simply ignored or considered optional. One recent study (MacDonald, 1981) in which teachers indicated those parts of mathematics teaching which they considered difficult might be expected to shed light on such a possibility. However, although the NSW Infant and Primary teachers (N=54) surveyed identified not one spatial topic as a problem area, the interpretation is confounded. This finding could mean that spatial topics genuinely presented no difficulty, that spatial relations was not taught, or even that spatial topics were not considered to be a part of mathematics.

A second way in which Dettrick's finding of poor performance on the Spatial Relations subtest might be explained is to point to the possibility that, in concert with the overall survey, an inappropriately large proportion of the Spatial Relations items were pitched at an Upper Primary level. Such of course would necessarily disadvantage a significant component of Dettrick's sample of teachers, and as a consequence provide a biased measure of teachers' competence with the spatial topics that they actually teach.

To summarise: the literature reviewed in this section reveals a picture consistent with that revealed in Section 2.2.2, that usually the studies have not paid sufficient

attention to the two questions of the distribution of geometry items appropriate to the grade range of the teacher sample and the preferred grade or teaching level of the teacher sample.

#### 2.2.4 Summary

Section 2.2 has reviewed the main studies of teacher geometry competence, those which have considered it incidentally to some other concern, and finally, the geometry subtests of two of the comprehensive mathematics competence surveys reviewed in Section 1.6. In summary, it can be said that these investigations have often suggested deficiencies in teacher and student teacher geometry competence, and that Hook's criterion of 'intellectual competence' would seem to have often not been met.

### 2.3 Geometry Competence and Spatial Abilities

In this section studies on relationships between geometry competence and spatial abilities are reviewed. As indicated in Section 1.3.2, spatial abilities are here considered to be neither necessarily dependent on training nor on specialised knowledge, a view also shared by most of the studies cited so far.

There has been considerable research concerning the possible links between mathematics competence and spatial abilities. This research has followed a number of different lines. Some studies have involved training in one of mathematics or space with a view to detecting changes in the

other. Other studies have been concerned with elucidating relationships between a general intelligence factor and mathematical ability. Still other studies have been concerned with aptitude-treatment interactions. Mostly, however, these studies have involved mathematics in a broader sense than is the concern of this thesis. Consequently, only those studies which have attempted to relate spatial abilities to a distinctly geometric component will be reviewed in this section.

While there were a number of investigations into the nature of mathematical competence and spatial abilities prior to World War II, they often had other primary aims, and they sometimes confused what constituted a 'spatial' task and what constituted a 'geometric' task. Only a selection of these studies are thus pertinent here. Blackwell (1940), in a factor analytic study, found no significant overlap between his spatial test and a geometry subtest other than that which could be accounted for by a general intelligence factor. However, Parslow (1942) found that Blackwell's results held only for the girl subsample; with boys he found geometry examination marks to be associated with spatial scores.

Post-war, Holzinger and Swineford (1946) found correlations of .23, .46 and .69 between tests of spatial ability and tests of geometry, shopwork, and drawing, respectively. However, the usefulness of this data is open to question because the tests used suffered from definitional ambiguities as to what constituted spatial and geometry tests, difficulties which the authors acknowledged.

Murray (1949) investigated the intercorrelations among an objective assessment test (the Geometry Test), end of semester grades (the Terminal Grades), age, Alpha V (a verbal measure), Alpha N (a numerical measure), a reasoning test, and a spatial relations test (Minnesota Paper Form Board Test). The sample ( $N=255$ ) were Grade 7 boys from three High schools in New York City. The correlations are given in Table 2.3.

The relatively small correlation found between the Geometry Test and the Spatial Relations Test, and the further finding that the correlations of Alpha N with the Geometry Test and Terminal Grades (.370 and .364, respectively) were higher than those of Spatial Relations with these two measures, (.283 and .271, respectively), led Murray to conclude:

From a superficial examination of geometric achievement, it is a popular notion that spatial relations plays the predominant role in such achievement. The results of this study, however, lend no evidence to support this idea.

One can speculate on the reasons for this perhaps surprising result. Perhaps Murray's Geometry Test had a high verbal content and a low diagrammatic content. Perhaps also the Terminal Grades were based on a high numerical understanding. Whatever the reasons, the fact remains that Murray's findings are at variance with many other studies which have indeed shown the expected correlations between geometry and spatial tests (e.g., Smith, 1964). Barakat (1951) administered a battery of tests to a large grammar



Table 2.3

Correlation Matrix for the Variables from Murray (1949)

Variable	Terminal Grades	Spatial Relations	Reason- ing	Alpha N	Alpha V	Geometry Test
Terminal Grades						
Spatial Relations	.271					
Reasoning	.202	.240				
Alpha N	.364	.140	.475			
Alpha V	.290	.251	.541	.426		
Geometry Test	.608	.283	.378	.370	.430	
Age	.062	.094	-.092	-.084	-.041	.023

school sample and found that for girls the geometry test loaded the second highest (.269) on the bi-polar factor which separated spatial abilities from verbal abilities. The highest loading on the spatial factor was .285 for one of the spatial tests. Although for boys the overall results from the factor analysis were not quite so clear cut, the same high geometry loading on the spatial factor was observed. Smith (1948, 1954) found that correlations between spatial tests and geometry tests were higher than for correlations between spatial tests and tests of arithmetic and algebra. Both Wrigley (1958) and Werdelin (1958), similar to Barakat (1951), found that geometry loaded high on spatial factors.

Battista, Wheatley and Talsma (1982) investigated the relationship between spatial competence and geometry performance with Elementary student teachers ( $N=82$ ). They tested the sample prior to a semester geometry course with a spatial test, S1. At the end of the geometry course the student teachers were tested with a geometry test, G, a cognitive development test, C, and a repeat of S1, called S2. Table 2.4 is the correlation matrix for S1, S2, C, and G. Even though C had the largest correlation of the three variables with G, those between G and S1 and S2 were nevertheless both large and significant also.

To summarise this section it can be said that most studies which have attempted to relate geometry competence and spatial abilities have found them to be positively correlated. Those variant findings which have occurred can perhaps

Table 2.4

Correlation Matrix for Variables from Battista,  
et al. (1982)

(N = 82)	S <sub>1</sub>	S <sub>2</sub>	C	G
S <sub>1</sub>	1.00	.77**	.31*	.39**
S <sub>2</sub>		1.00	.45**	.42**
C			1.00	.51**
G				1.00

\*  $p < .01$ .

\*\*  $p < .001$ .

S<sub>1</sub>, Spatial Pre-test

S<sub>2</sub>, Spatial Post-test

C, Cognitive Development Test

G, Course Grade Score

be best interpreted as suggesting that in any research dealing with spatial tests and geometry tests it would seem important to choose or devise tests which do not overemphasise such things as numeracy and verbal skills.

#### 2.4 Teacher and Student Teacher Geometry Competence:

##### Two Research Suggestions

There seem to be at least two gaps in the research literature with respect to teacher and student teacher geometry competence. The first, revealed in Section 2.2, relates to two aspects of the description of teacher and student teacher geometry competence. The tests typically used have invariably contained items disproportionately weighted towards the Upper Primary grades, if not beyond; and in the analysis of test performances no distinctions are typically made regarding the preferred or intended grade level of responsibility of the teacher or student teacher sample. It would seem a comparatively simple matter to remedy these two deficiencies. One would need only to devise or use a geometry test for Infant and Primary teachers having items distributed more evenly over the grade range and based on local mathematics or geometry syllabi. With such a test, teacher geometry competence, both over the entire grade range and in relation to the preferred grade or level of teaching, could be readily described.

The second gap concerns, in part, the relationship between spatial ability and geometry competence. In Section 2.3 it was seen that most surveys which have researched pupil

or student teacher geometry competence and spatial abilities have usually reported positive correlations. This would indicate that it may be possible to view teacher and student teacher geometry competence as having at least two components, a spatial abilities component and a trained or syllabus-specific component. Such a view, if able to be supported could have implications for inservice and pre-service geometry education at the Infant and Primary levels. A first implication might be that it would be proper for inservice and pre-service teacher geometry education to explicitly consider both these components. Such does not however accord with current practice in Australia. Inservice and pre-service teacher geometry education is typically given a very much lower priority than number, and thus the little time left to it is usually considered best spent on topics which fit the syllabus-specific component.

A second implication relates to research concerning teacher or student teacher geometry competence. When investigating relationships between geometry competence and spatial abilities, it might prove useful to use spatial abilities test scores as a 'control' on geometry test performance so that the 'remaining' or 'adjusted' geometry test score is thus free of spatial abilities variance, and hence has a higher proportion of variance attributable to syllabus-specific knowledge.

## CHAPTER 3

### AIMS OF THE RESEARCH

#### 3.1 Introduction

There are two main aims in the present research. The first, in Section 3.2, is the description of teacher and student teacher Spatial Awareness competence (see 1.3.1 previously). The second aim, Section 3.3, is an investigation of relationships between this competence and a range of potentially explanatory variables.

#### 3.2 A Description of Teacher and Student Teacher Spatial

##### Awareness Competence

##### 3.2.1 Teacher Spatial Awareness Competence

The first aim of this study is a description of teacher competence on a test based on the Spatial Awareness strand of the (Tasmanian) Primary Mathematics Guidelines and subsequent Spatial Awareness material published by the Tasmanian Department of Education. (A copy of the strand is included as Appendix A and the titles of the additional material are listed in Appendix B.) This will involve the usual descriptive statistics (mean, standard deviation, range, etc.) as well as information on the percentage of teachers who scored less than 50% and 75% correct. There will also be information on the percentage correct for each question.

Following the suggested division in the Guidelines, teachers will be divided on the basis of their preferred level of teaching into Infant, Middle Primary, or Upper Primary, and the above mentioned statistical analyses will be repeated for their performance on their relevant subtest - Infant, Middle Primary or Upper Primary. This should give an indication of teacher competence with the Spatial Awareness topics they teach, or are expected to teach.

As the errors of teachers on questions from their relevant subtest could give pointers to basic misunderstandings, the three most difficult questions from each of the three teaching levels will be chosen for error tabulation and brief comment.

### 3.2.2 Student Teacher Spatial Awareness Competence

The analyses of the preceding section for teachers are repeated with another sample, (Tasmanian) Year IV Infant and Primary student teachers. Initially there will be a description of student teacher Spatial Awareness competence. Next there will be a description of competence on the relevant subtests for two levels of student teacher training, Infant and Primary. Altogether there are six teacher training courses from the two Tasmanian teacher training institutions at these levels. They are:

- (i) the Tasmanian College of Advanced Education (TCAE) Bachelor of Education (B.Ed.) Infant Method course,

- (ii) the TCAE B.Ed. Primary Method course,
- (iii) the University of Tasmania (U of T) Diploma of Education (Dip. Ed.) Infant Method course,
- (iv) the U of T Dip. Ed. Primary Method course,
- (v) the U of T B.Ed. Infant Method course, and
- (vi) the U of T B.Ed. Primary Method course.

A number of specific hypotheses relating to student teacher competence will also be tested. The 'S' before the hypotheses refers to student teachers.

SHo1. The three groups of Infant student teachers (TCAE, U of T Dip. Ed., U of T B.Ed.) do not differ significantly on (i) total test score and (ii) Infant subtest score.

SHo2. The three groups of Primary student teachers (TCAE, U of T Dip. Ed., U of T B.Ed.) do not differ significantly on (i) total test score and (ii) Primary subtest score.

The errors of student teachers on questions from their relevant subtest will also be considered. The three most difficult questions from each of the two teaching levels will be chosen for error tabulation and brief comment.

### 3.2.3 Comparisons between Teacher and Student Teacher

#### Spatial Awareness Competence

The first comparison between the samples will be on



overall test performance. The 'T' before the hypotheses refers to teachers.

T&SHo3. Teachers and student teachers do not differ significantly on total Spatial Awareness test score.

Comparisons will also be made on the basis of teaching level.

T&SHo4. Infant teachers and Infant student teachers do not differ on (i) total test score and (ii) Infant subtest score.

T&SHo5. Primary teachers and Primary student teachers do not differ on (i) total test score and (ii) Primary subtest score.

### 3.3 The Relationship between Spatial Awareness

#### Performance and Other Variables

##### 3.3.1 Teacher Spatial Awareness Performance and Other Variables

Research in this area, e.g. Weaver (1966), Backman (1969), Keith (1970) and Dettrick (1981), has investigated relationships between teacher mathematics or geometry test score and potential explanatory variables. A similar investigation is part of the present research. The dependent variable will be total test score on Spatial Awareness. Total test score, and not a subtest score, will be used because the concern here is with predictive relationships to overall Spatial Awareness performance.

The explanatory variables in the study will be of two types, 'measured' variables and 'factors' (Finn and Mattsson, 1978). There will be two measured variables, a spatial

abilities score and age. Although, strictly speaking, it could be argued that in this study age was not a measured variable it was felt that, as there were eight categories of age, each encompassing five years, for practical purposes it could be thus considered. There will be nine factors, sex, secondary mathematics background, type of teacher training, level of teaching, upgrading of initial qualifications, years of teaching, classroom responsibility, school size, and feedback of results.

The measured variables will be used to give an indication of the way in which they can 'predict' or 'account for' Spatial Awareness performance. Two hypotheses relating to regression will be tested. In the null form they are that there is no significant difference in the amount of variation explained in teacher test score by (i) spatial abilities score over and above that which can be explained by the constant term, and (ii) age, over and above that which can be explained by spatial abilities score and the constant term in the regression equation. These are THo6 and THo7, respectively.

Recall that in Section 2.4 it was suggested that teacher Spatial Awareness score might be viewed as having at least two components, a spatial abilities component and a syllabus-specific component. If spatial abilities proves to be a significant predictor in the above regression analysis, then Spatial Awareness scores will be 'adjusted for' spatial abilities influence. In similar fashion, should age prove to

be a significant predictor, its influence will also be 'adjusted for'. The resultant adjusted Spatial Awareness scores will then be used as a dependent variable in a series of analyses investigating the possible effects of the listed nine factors. That age will also be considered as a potential predictor is because it was thought desirable to maintain parallel analyses between the teacher and student teacher samples. The importance of age as a potential predictor for student teachers will be explained shortly.

In null form, the hypotheses to be tested are that there are no significant differences on 'adjusted' test score between subsamples of teachers formed according to:

- (i) sex,
- (ii) secondary mathematics background,
- (iii) training background,
- (iv) level of teaching,
- (v) upgrading,
- (vi) years of teaching,
- (vii) classroom responsibility,
- (viii) school size, and
- (ix) feedback.

These are THo8 to THo16, respectively.

### 3.3.2 Student Teacher Spatial Awareness Performance and Other Variables

The preceding analyses for teachers will be repeated for student teachers, but with a few modifications imposed by the different nature of the sample. The regression analysis will

test similar hypotheses, spatial abilities test score, and age. Age was of interest as a potential predictor because of the number of mature age student teachers. Two regression hypotheses will be tested. In the null form they are that there is no significant difference in the amount of variation explained in student teacher Spatial Awareness scores by (i) spatial abilities score, and (ii) age, over and above that which can be explained by the constant in the regression equation. These are SHol7 and SHol8, respectively.

As with the teacher analyses above Spatial Awareness will be 'adjusted for' influences from the measured variables, and the resultant adjusted scores will be used in analyses of factor effects. For the student teachers, however, there will be only four factors, sex, course of study, feedback, and secondary mathematics background.

In the null form, the hypotheses tested will be that there are no significant differences on 'adjusted' Spatial Awareness scores between subsamples of student teachers formed according to

- (i) secondary mathematics background,
- (ii) course of study,
- (iii) feedback, and
- (iv) sex.

These are SHol9 to SHo22, respectively.

## CHAPTER 4

### THE SURVEY

#### 4.1 Introduction

In this chapter the development of the Spatial Awareness Teaching Test (SATT) and the survey procedures are outlined. In Section 4.2 a description of the development of SATT is given as well as its trial testing with the staffs of three schools. The data from this testing is briefly analysed and the modifications to the trial version of SATT are described.

In Section 4.3 two spatial tests, the Monash Spatial Test 1 (MST1) and Monash Spatial Test 2 (MST2), are briefly described. These tests were trialled with teachers so that the more appropriate test could be used in conjunction with SATT.

In Section 4.4 a brief description of the main teacher sample is given together with the survey procedure used. Finally, in Section 4.5 a brief description of the fourth year student teacher sample is given and their survey procedures described.

#### 4.2 The Spatial Awareness Teaching Test

##### 4.2.1 The Spatial Awareness Strand

The (Tasmanian) Primary Mathematics Guidelines were issued in 1978 and replaced the 1966 A Programme for Primary

School Mathematics. From the point of view of this study the main change was the shift in emphasis from literally 'Spatial Knowledge' to literally 'Spatial Awareness', that is, away from spatial concepts treated as precursors to Euclidean geometry, to an almost informal appreciation of the way pieces of 3D and 2D space and area fit together. The new content was presented in a Piagetian developmental context. A copy of the Spatial Awareness strand and its accompanying Topics and Activities are included as Appendix A. The new Spatial Awareness strand comprises three bands. The upper-most band covers the suggested Infant (K-2) range, the middle band the suggested Middle Primary (3-4) range, while the lower band covers the suggested Upper Primary (5-6) range.

As the term 'Guidelines' implies the syllabus was meant to be more of a guide or starting point than a definitive or detailed document. Even its folder format allowed for addition and deletion and, in fact, since its initial distribution there have been a number of widely disseminated booklets printed by the Tasmanian Education Department containing extra material (see Appendix B).

#### 4.2.2 Criterion-Referenced Testing

In education and psychology a distinction is made between two main types of tests, norm-referenced and criterion-referenced. Norm-referenced tests relate an examinee's performance to those of a previously tested large group of examinees, that is, to something outside the test itself. Criterion-referenced tests, on the other hand, attempt to reveal the

kinds of skills, knowledge or abilities an examinee has or does not; irrespective of his or her standing relative to some other group (Glaser, 1963; Nitko, 1980). It was decided to construct a criterion-referenced test for two main reasons. First, teacher geometry competence could be operationalised with respect to a 'well defined domain' (Nitko, 1980), viz. the Spatial Awareness strand. Second, the intent of the study was not to rank sample performances relative to some norm group, but rather to simply describe the extent to which teachers and student teachers had mastered the topics of the Spatial Awareness strand.

#### 4.2.3 The SATT (Pilot Versions) - Form A and Form B

The Topics and Activities of the Spatial Awareness strand of the Primary Mathematics Guidelines and subsequent Spatial Awareness material published by the Tasmanian Education Department were grouped into a smaller number of related themes (see Appendix C). The original three-fold classification of material into Infant, Middle Primary and Upper Primary was however adhered to. Questions which appeared to relate to each of the themes were then assembled. These came from a number of sources: previously cited U.S. research into teacher and student teacher mathematics or geometry competence, Dettrick's (1981) study, the Australian Council for Educational Research (ACER), the (U.S.) National Assessment of Educational Progress (NAEP), and items specifically devised for the present study.

Nine people, prominent in their involvement in Tasmanian

Infant and Primary mathematics teaching, were asked to become members of a content validation group to assist in devising a trial version of SATT. These were the three members of the original writing team of the (1978) Guidelines, the State Supervisor of Mathematics in the Tasmanian Education Department, the Curriculum Officer in Primary Mathematics in the Tasmanian Education Department, a Principal of a Hobart Primary School who had previously been Principal of an Infant School, a Principal of a rural Primary School who had previously been associated with pre-service mathematics education at the Infant and Primary levels, and a Primary mathematics education staff member from each of the University of Tasmania's Department of Teacher Education and the Tasmanian College of Advanced Education. Eight of the nine agreed.

The initial task of this group was to judge the relative suitabilities of potential text items. Group members were instructed as follows.

"For each Theme there is a sheet with up to four possibly useful questions. You may wish to comment on:

- (i) the treatment of the additional material,
- (ii) the thematic groupings,
- (iii) the questions in relation to the theme,
- (iv) the wording or graphics of each question,
- (v) the level of knowledge needed to successfully answer the question relative to mastery of or familiarity with the content of the Spatial Awareness strand, and
- (vi) any other matter that you think worthy of comment.



As well, you are invited to submit questions for any theme. Where there are more than two questions you may wish to rank them according to suitability."

Comments on the thematic groupings and questions were collated and it was found that there was enough material for two parallel forms for SATT (Pilot Version) - Form A and Form B. It was decided to retain these two parallel forms so that when testing in staffroom situations alternate forms could be distributed in order to minimise copying. Copies of SATT (Pilot Version) - Form A and Form B were then submitted to the validation group for further comment. The few comments that were made resulted in only minor changes.

The SATT (Pilot Versions) are enclosed as Appendix D. There were 36 items in each test, 12 each for the Infant, Middle Primary and Upper Primary subtests. As well there were 12 items common to each test, four in each of the three subtests. Where questions were not common, the same numbered question in each form referred to the same Theme.

Table 4.1 is a classification of items by source. In some instances borrowed items were amended. Most of the items were original.

Table 4.1

The Source of Items used in SATT (Trial Versions)

	ACER	Dettrick	NAEP	Banning	Bailey	Original	Sum
Form A	12	1	-	1	-	22	36
Form B	12	-	2	1	1	20	36

#### 4.2.4 Testing of SATT (Pilot Version) - Form A and Form B

Three principals of Primary Schools in Tasmania were asked to allow their staff to act as pilot subjects on a version of SATT. It was explained that the tests were Pilot Versions based on part of the Primary Mathematics Guidelines, and that comments on the test items regarding things like expression, difficulty or relevance in teaching would be both possible and welcome. The principals were told that the results of the testing and the comments would be used in devising a final version of the test to be used in the main part of the present research project. They were also asked that their staffs be requested to complete an associated questionnaire to help with the processing of the data gained from the test. The questionnaire responses would be used to improve it for use in the later study proper. Confidentiality and anonymity were assured. Further, the approval of the Tasmanian Director-General of Education to approach schools concerning this research was conveyed.

The three schools were chosen on the basis of proximity to the University, and the present writer's personal acquaintance with either the Principal or staff members as a result of previous inservice mathematics work.

All three Principals, together with their staffs consented. All staffs were tested in lieu of a normal staff meeting. The total sample size was 38. Standardised instructions were read to the teachers prior to the commencement of the tests

(see Appendix I). The two forms of SATT (Pilot Version) were distributed alternately. Time taken to complete each version varied from 35 minutes to a little over one hour. The tests were done in the presence of the author in November and December, 1981.

#### 4.2.5 Results of Testing SATT (Pilot Version) - Form A and Form B

Each item was worth one mark, so the tests were scored out of a possible 36. Items which had more than one part to them had to have every part correct for the item as a whole to be correct. Table 4.2 shows a summary of results for each form of SATT (Pilot Version) together with pooled results.

While these data may be of some interest, the primary concern of the study at this stage was the proportion of correct answers for each question. These data are in Table 4.3. Questions were divided into three groups on the basis of percentage correct, easy, medium and difficult. The easy questions, those which were answered correct by greater than or equal to 90% of teachers, were questions 1, 2, 11, 16, 18 and 30 in Form A, and questions 2, 4, 5, 18, 20 and 23 in Form B. Difficult questions, those which were answered correctly by less than or equal to 10% of teachers, were question 23 in Form A and question 19 in Form B.

It was decided to retain all of the easy and medium questions. They were felt to be acceptable questions given the criterion-referenced nature of SATT. While norm-referenced test theory would suggest that easy questions are usually

Table 4.2

## Summary of SATT (Pilot Version) Results

	Form A	Form B	Pooled
N	18	20	38
$\bar{x}$	21.83	22.75	22.32
s.d.	4.18	6.17	5.27
Range	28-13=15	32-8=24	32-8=24
% scoring less than 50% (18/36)	11.1% (2/18)	20% (4/20)	16% (6/38)
% scoring less than 75% (27/36)	83.3% (15/18)	60% (12/20)	71% (27/38)

Table 4.3

Percentage Correct on each question of SATT (Pilot Version) -  
Form A and Form B

Subtest	Question No.	Form A (N = 18)	Form B (N = 20)	Common Questions (N = 38)
Infant	1	94	40	
	2*	100	100	100
	3*	67	60	
	4	22	90	
	5	56	90	
	6	61	85	
	7*	39	25	32
	8	78	80	
	9	50	50	
	10	72	65	
	11	94	70	
	12*	17	20	19
Middle Primary	13*	56	55	55
	14	28	35	
	15	61	65	
	16	100	55	
	17*	56	50	53
	18	94	95	
	19	78	0	
	20	78	90	
	21*	61	65	63
	22*	67	65	66
	23	0	95	
	24	67	65	
Upper Primary	25*	33	35	34
	26	67	80	
	27	33	40	
	28	67	65	
	29*	78	70	74
	30	100	85	
	31	39	30	
	32	89	70	
	33	89	80	
	34*	17	20	18
	35	17	85	
	36*	33	70	53

\* indicates a common question

poor discriminators, criterion-referenced test theory has another concern, that of giving an indication of competence with respect to a 'well defined domain' (Nitko, 1980). Moreover, they were felt to be acceptable given the content of the Spatial Awareness strand and the views of the validation group on necessary or desirable skills in teachers. The third or difficult group contained two questions. These were each replaced in turn by a question, hopefully easier, belonging to the same theme.

For a number of reasons it was also decided to retain two parallel forms for the final version of SATT. First, there were sufficient questions for two forms. Second, two forms meant that teachers in large Infant and Primary Schools could receive two different SATTs, thus minimising the chances of answers being copied. Third, two forms could be used alternately when testing student teachers, which could again minimise the chances of copying. Fourth, the larger range of questions in two forms of SATT might perhaps provide a better means of revealing teacher competence on a particular theme or themes. That is, with a single question per theme it might be difficult to separate teacher ability on the item from teacher ability on the theme.

#### 4.2.6 Teacher Comments on SATT (Pilot Version)

Recall that teachers were invited to make written comments on the questions and the test. Few comments were made about the questions and they mostly concerned definitions. A few noted how spatially "stimulated" they felt by the test.

By default, then, it was assumed that teachers agreed that the questions related reasonably well to the target Spatial Awareness strand.

There were some comments concerning the questionnaire. Several teachers pointed out that the range of possible training backgrounds was not adequately catered for. Specifically, there was a lack of questions relating to upgrading of initial qualifications. The questionnaire was subsequently modified to remedy this. Some teachers also commented that feedback on their performance might be welcomed so the questionnaire was further modified to provide for this option to be indicated.

#### 4.2.7 The Final Version of SATT - Form A and Form B

The two forms of the final version of SATT are included in Appendix E. Each contains a changed question in comparison with the Pilot Version. In Form A this was question 23 and in Form B question 19. The main changes in the questionnaire were to make provision for information relating to upgrading of initial qualifications, and to allow respondents to indicate whether they wished to know their test results.

Table 4.4 is a classification of items by source. (Compare Table 4.1 in Section 4.2.3.) The source of each question is given in Appendix G. A list of the items for which ACER copyright permission was given is included in the SATT booklets in Appendix E.

To summarize; on the final SATT versions, as for the pilot versions, there were 36 items on each test, 12 each for



Table 4.4

The Source of Items Used in SATT (Final Version)

	ACER	Dettrick	NAEP	Banning	Bailey	Original	Sum
Form A	13	1	-	1	-	21	36
Form B	12	-	2	1	1	20	36

the subtests Infant, Middle Primary and Upper Primary. Twelve items were common to each test, 4 in each of the 3 subtests.

### 4.3 A Suitable Spatial Abilities Test

#### 4.3.1 The Monash Spatial Tests

As concluded in Section 2.3, it seems that some of the previous research into the relationships between geometry competence and spatial abilities may have been at fault due to confusion over what should constitute test instruments of spatial abilities and geometry competence. For any real relationships to be able to be established between these two aspects of human ability, it would seem that they must be first distinguishable both conceptually and operationally.

Geometry has a unique history, pedagogy and content separate from the other branches of mathematics and other forms of knowledge. While it is readily conceded that the content of the Spatial Awareness strand is not sophisticated or advanced geometry but is instead concerned with perhaps pre-geometry, it is nevertheless clearly "geometrical" in these epistemological, historical and pedagogical senses. Furthermore, it is "geometrical" in its intent and the uses to which it will be put in the Upper Primary School, the High School and in later life. On the other hand spatial abilities is here thought of as the ability to manipulate simple or relatively simple mental images without the specialised knowledge or concepts of, for example, engineering, technical drawing or especially geometry. Recall the definition of

that historically many geometrical problems were originally solved using spatial abilities (Hadamard, 1954) and many Primary School, High School and trade geometrical problems are perhaps most efficiently solved by the use of spatial abilities. But, of course, such is only one way of solving geometrical and pre-geometrical problems. They can typically be solved visually (Clements, 1981) or analytically (Richardson, 1977). So, in brief, SATT here is distinguishable conceptually from spatial abilities in that it is concerned with geometrical content rather than the particular cognitive processes employed to deal with that content.

In deciding on a suitable spatial test for the present study, the need to select one which maintained this conceptual distinction, and which operationalized it in relation to the test items employed, was clear. Amongst the spatial tests considered two related tests seemed especially suitable, the Monash Spatial Test Form 1 (MST1) and the Monash Spatial Test Form 2 (MST2). These were devised by Clements and Wattanawaha (Wattanawaha, 1977; Wattanawaha & Clements, 1982). Both tests were highly diagrammatic with a minimum of written instructions. As well, since they had been used by Wattanawaha (1977) with Grades 7, 8 and 9 pupils in Victoria it was assumed that there would be few, if any, comprehension problems for teachers and student teachers. Another feature was that they were both designed to be completed in less than 40 minutes, an important practical consideration.

It is noteworthy that Grieve (Clements, 1978) had used

MST1 in a factor analytic study along with 12 other tests (there were three 'Spatial Visualization' tests, three 'Spatial Orientation' tests, three 'Spatial Scanning' tests, and three 'Verbal Fluency' tests) with 216 thirteen year-olds in Victoria. It can be seen from Table 4.5 (in which factor loadings less than .30 and the decimal points have been deleted) that MST1:

"is the 'purest' so far as factor 1 is concerned, where purity is reflected by (i) its high loading on factor 1 (it is marginally greater than the loadings for the three 'Spatial Visualization' tests), and (ii) the absence of significant loadings on factors 2 and 3 (note that the three 'Spatial Visualization' tests all have significant loadings on factor 2)." (Clements, 1978)

It therefore seemed that MST1 might be the most suitable of the 'Spatial Tests' used because it measured that aspect of human ability commonly considered as 'spatial ability' the best. However, as MST1 and MST2 were similar in many respects it was decided to trial both of these tests with teachers to see which, if either, was the more suitable. Copies of MST1 and MST2 are included in Appendix H.

#### 4.3.2 Trial Testing of the Monash Spatial Tests

The principals of eight Primary Schools in Tasmania were contacted seeking permission to approach their staffs as potential trialing subjects. It was pointed out that the results of this trial testing would help in determining the more appropriate spatial test to be used in the study proper. Confidentiality and anonymity were assured. As well the approval of the Tasmanian Director-General of Education to

Table 4.5

Factor Loadings for the Test Battery in Grieve's Study (1978)

Test	Factor 1	Factor 2	Factor 3	$h^2$
VZ1	61	39	-	54
OR1	41	30	-	27
VZ2	66	31	-	54
OR2	32	75	-	69
OR3	31	75	-	67
VZ3	57	40	-	49
SS1	-	44	-	32
SS2	50	-	-	31
SS3	-	-	-	08
VF1	-	-	59	39
VF2	-	-	59	37
VF3	-	-	70	53
Wattanawaha	67	-	-	51
Eigen Value	4.689	1.537	1.071	
Percentage of Variance	36.1%	11.8%	8.2%	

VZ, Spatial Visualization

OR, Spatial Orientation

SS, Spatial Scanning

approach schools concerning the research was conveyed. The schools, none of which were involved in the testing of SATT (Trial Versions), were chosen on the basis of the present writer's acquaintance with either the principal or staff members because of inservice mathematics education done during the preceding few years.

All principals consented to the testing and the majority of staff members in all the schools consented to the proposals. Tables 4.6 and 4.7 are a list of schools, their staff numbers and the number of those who participated in the spatial testing. It can be seen that only a few teachers did not wish to be tested.

Prior to testing, Wattanawaha's (1977) standardised instructions (Appendix I) were read out. All teachers finished inside the time limit. Testing occurred during August and September, 1981.

#### 4.3.3 Results of the Trial Testing

Each item was worth one mark and items which had more than one part to them had to have every part correct for the item as a whole to be correct. Table 4.8 is a summary of results for MST1 and MST2. It can be seen that MST1 was the more difficult, but since it also yielded a broader range of scores it was judged to be the better of the two for the purposes of the present study.

Table 4.6

Number of Teachers involved in Trial Testing of MST1

School	Possible	Actual
A	11	11
B	4	4
C	20	20
	Sum = 35	Sum = 35

Table 4.7

Number of Teachers involved in Trial Testing of MST2.

School	Possible	Actual
D	5	5
E	8	7
F	3	2
G	2	2
H	12	6
Sum =	30	Sum = 22



Table 4.8

Summary of Trial Testing of MST1 and MST2

	MST1	MST2
N	35	22
$\bar{x}$	17.09	19.39
s.d.	4.40	3.65
Range	23-8=15	24-12=12
% scoring less than 12 (50%)	17% (6/35)	0% (0/22)
% scoring less than 18 (75%)	49% (17/35)	27% (6/22)

#### 4.3.4 Monash Spatial Test 1

The spatial test MST1 used in the main survey was unchanged from the version used for trial testing and unchanged from that used by Wattanawaha (1977).

To reiterate, MST1 was a 24 item test of spatial abilities with a 40 minute time limit. A copy of it is included in Appendix H.

#### 4.4 The Teacher Sample and the Main Survey Procedure

For the main survey it was decided to use as large a sample size of the population of Tasmanian Infant and Primary teachers as financial and other resources would allow. As the population was approximately 2300 a 1-in-10 random sample was settled for. This would give a sample size of approximately 230. A Tasmanian Education Department Infant and Primary School staff list compiled during February and March, 1982 was inspected and every tenth name recorded. This became the list which formed the survey sample (N=233) for teachers. Several chi-square tests of proportion confirmed that the sample was representative from a number of points of view; male/female, distribution by the three administrative regions (North, North-West, South) and size of school (Class VI, the smallest, to Class IA, the largest).

As individual testing would have been beyond the resources of the project it was decided to survey teachers by post. Recall that Keith (1970) adopted the same approach. Although it was realised that there could be no guarantee of teacher adherence to the request for informal or relaxed examination

conditions it was felt that there was no other option.

The procedure advocated by Robin (1965) for postal surveys was adopted. This consisted of a minimum of two contacts and a maximum of five (later modified to four) contacts with the sample. The first contact with the sample was with a pre-test letter (see Appendix J). This indicated to the teachers that they were part of a 1-in-10 random sample of Tasmanian Infant and Primary teachers and that they were being asked to assist in some mathematics education research. They were informed that some test booklets would shortly arrive, and they were asked to complete them and the associated questionnaire. These were to be returned in the stamped addressed envelope as soon as convenient. The letter invited teachers to contact the author if they wanted further information about the project. That the research had the approval of the Tasmanian Director-General of Education and the support of the Tasmanian Teachers' Federation was indicated.

The second contact (Appendix J) occurred one week later. This comprised test booklets for both SATT and MST1, and a questionnaire seeking information on the respondent's background (see Appendix E). It was stressed that it was important for all members of the sample to complete the test booklets so that the group's responses could be taken as representative. The sample was invited to comment on individual SATT questions and the test as a whole. Also, subjects were informed that they would be told of their test results

if they indicated such.

As well as the covering letter and the two tests, there were copies of the standardised instructions to be read before completing each test and a copy of a letter from the President of the Tasmanian Teachers' Federation giving the Federation's endorsement of the research. Both confidentiality and anonymity were assured.

The third contact (Appendix J) was a brief reminder sent one week after dispatch of the tests. The fourth contact and second reminder was sent one week later still, that is, two weeks after dispatch of the tests. This second reminder was longer and more explicit than the first. It restated the importance of all sample members returning the completed tests so that the results might be truly representative of all Tasmanian Infant and Primary teachers. Again teachers were invited to contact the author if further information was required (see Appendix J).

The fifth contact advocated by Robin was a telephone call to be made to defaulters, but this was not used here. It was felt that the approximately 80% response rate achieved by the time of one week after the dispatch of the second reminder, that is, three weeks after the dispatch of the test booklets, was adequate for the purposes of the study.

Prior to the sample's first contact a small article was written by the author and published in the June, 1982 issue of the monthly newspaper of the Tasmanian Teachers Federation, The Tasmanian Teacher. It briefly explained the

research and forewarned teachers of their possible involvement. A copy of this is also included in Appendix J.

#### 4.5 The Student Teacher Sample and the Main Survey Procedure

The population of Tasmanian fourth year Infant and Primary student teachers was also tested. Testing student teachers during their training might provide potentially useful feedback to the two teacher training institutions as well as to individual students. This was felt to be of particular value since Spatial Awareness received only a small part of mathematics teacher training time, and thus would not have been either intensively or extensively taught or examined. The criterion-referenced nature of SATT had the potential to pinpoint student teacher competence not only with the whole strand but also in relation to intended level of teaching.

As much of the questionnaire for teachers was not relevant for student teachers a more appropriate one was substituted (see Appendix E).

The six groups of student teachers tested were those listed in Section 3.2.2. The two TCAE courses and the two U of T B.Ed. courses were four year 'integrated' courses in that elective academic studies, e.g. Social Science, English, General Science, Mathematics, Drama, Physical Education, etc. were integrated with education theory and practice. The two Dip. Ed. courses were post graduate diplomas usually undertaken after three or four years of an initial University degree typically in Arts Science or Economics and

Commerce. X

Testing was done in lieu of normal class times except for the two TCAE groups who were specially summoned from part of their practicum. Each group was read the standardised instructions for the two tests prior to testing. The 40 minute time limit for MST1, the first test attempted, was never exceeded. The two forms of SATT were allocated alternately. Time taken to complete SATT varied from 35 minutes to 65 minutes. Numbers of students in each group are given in Chapter 5.

## CHAPTER 5

## RESULTS AND THE TESTING OF RESEARCH HYPOTHESES - I

5.1 Introduction

In this chapter the performances of teachers and student teachers on SATT and MSTI are described. As well, the first group of research hypotheses are tested. The first part of the chapter, Sections 5.2 to 5.4, describes the attributes of the teacher respondents and their performance on SATT, the relevant SATT subtest and MSTI. Next, in Sections 5.5 to 5.7, student teacher attributes and performance are described. In Section 5.8 a brief summary of teacher and student teacher comments on SATT is given. In Sections 5.9 and 5.10 comparisons are made between the performances of trial teachers, main survey teachers and student teachers. The errors of teachers and student teachers are tabulated and briefly discussed in Section 5.11. Finally, Chapter 5 is summarised in Section 5.12.

5.2 Attributes of Teacher Respondents5.2.1 Percentage Response Rate

Test booklets were posted on 30 June, 1982. By the end of week one (7 July) 96 completed tests and questionnaires out of 233 (41.32%) had been received. By the end of week two (14 July) an additional 46 completed booklets were received

making a total of 142 (60.9%). During week three (15 July to 21 July, inclusive) another 26 completed booklets were received. These brought the total to 168 (72.1%). By the end of week 4 (22 July to 30 July) another 10 completed test booklets were received. Altogether there were 178 respondents or 76.4% of the original sample.

However during this time a number of telephone messages and letters were received indicating that a number of the original sample were either no longer teaching or in some other way unable to complete the test booklets. Four of the original sample had resigned from teaching, the temporary appointment of one had been terminated, one was on accouchment leave and two others were on extended sick leave. These eight reduced the original sample of 233 to 225. Therefore the response rate was 178 out of 225 (79.1%). Surprisingly there appeared to be no transfers of teachers from one school to another. Few of the 47 defaulters made contact with the author. Four wrote and one rang giving various reasons, mostly shortage of time and energy. Three completed test booklets and questionnaires were received in mid-August, more than two weeks after the end of the last day of acceptance at the end of July.

None of the sample availed themselves of the repeated offer to provide further information about the project.



### 5.2.2 Grade Level Preferences

One concern of this project is the Spatial Awareness competence of teachers at their preferred level of teaching. Table 5.1 gives the number of teachers who indicated their level of teaching. Only 5.6% of teachers gave no response or an ambiguous response to this question.

### 5.2.3 Other Characteristics of the Respondents

Several other characteristics of the respondents are of note. There were 142 (79.8%) women and 36 (20.2%) men. Three quarters of the respondents (75.3%) wanted to know of their results in the two tests. There were more than nine different teacher training institutions. The most common were the University of Tasmania (25.8%), the Launceston Teachers' College (19.1%), the TCAE Newnham (18.0%) and the TCAE Mt. Nelson (12.4%). The modal class of respondents' ages was 25-29 (27.0%). Other age classes had these percentages: 20-24 (18.5%), 30-34 (12.9%), 35-39 (7.3%) and 40-44 (10.7%). Class IA schools, the largest, accounted for 36% of the respondents, class I 23.6%, class II 14.6%, class III 11.8%, class IV 7.9%, class V 3.9% and class VI, the smallest, 2.2%. The distribution of secondary mathematics background of respondents was also of interest. While the majority (62.3%) had completed only up to Grade 10, only 9% had not completed up to at least Grade 10.

Table 5.1

Number of Respondents at each Level of Teaching

	Form A	Form B	Pooled
Infant	40	42	82 (46.1%)
Middle Primary	17	17	34 (19.1%)
Upper Primary	22	30	52 (29.2%)
Ambiguous or No Response	6	4	10 (5.6%)
Sum	85	93	178

### 5.3 Teacher Performance on SATT

#### 5.3.1 Individual Items and SATT Form A and SATT Form B

Recall that there were two forms of SATT, Form A and Form B. The percentage correct for each question by the complete sample on each of the forms is given in Table 5.2.

It can be seen that the percentage of correct answers in Form A varied from 100% (q. 2) to 24.7% (q. 34). In Form B the percentage correct varied from 98.9% (qq. 2, 4, 20, 30 and 33) to 30.1% (qq. 12 and 25). For the common questions the percentage correct varied from 99.4% (q. 2) to 30.9% (q. 34). KR-20 test and subtest reliability coefficients for the teacher sample is given in Appendix M.

The possibility of treating SATT scores as single measures rather than keeping SATT Form A and Form B separate was considered. This simplification would seem reasonable if two criteria were met. First, only a small number of pairs of questions which related to the same theme, that is, identically numbered questions from Form A and Form B, could differ significantly in their proportion of correct answers. Second, those pairs of questions on the same theme which did differ significantly should not be concentrated into one of the three levels of teaching subtests.

Note that some of the identically numbered question pairs were in fact identical questions. These common questions (the asterisked questions in Table 5.2) will be treated first. In each case a corrected (using Yates' correction) chi-square value was calculated from a two (Form A and Form B) by two

Table 5.2

Percentage of Teachers Correct on each question of SATI  
Form A and Form B

Subtest	Question Number	SATI A (N = 85)	SATI B (N = 93)	SATI (N = 178)
Infant Subtest	1	97.6	93.5	95.5
	2*	100	98.9	99.4
	3*	80.0	78.5	79.2
	4	38.8	98.9	70.2
	5	52.9	96.8	75.8
	6	50.6	96.8	74.7
	7*	48.2	55.9	52.2
	8	96.5	97.8	97.2
	9	91.8	69.9	80.3
	10	81.2	48.4	64.0
	11	91.8	97.8	94.9
	12*	37.6	30.1	33.7
Middle Primary Subtest	13*	72.9	64.5	68.5
	14	55.3	65.6	60.7
	15	83.5	74.2	78.7
	16	98.8	63.4	80.3
	17*	72.9	72.0	72.5
	18	92.9	96.8	94.9
	19	98.8	61.3	79.2
	20	75.3	98.9	87.6
	21*	83.5	80.6	82.0
	22*	76.5	79.6	78.1
	23	96.5	95.7	96.1
	24	80.0	64.5	71.9
Upper Primary Subtest	25*	40.0	30.1	34.8
	26	84.7	80.6	82.6
	27	56.5	63.4	60.1
	28	77.6	83.9	80.9
	29*	85.9	87.1	86.5
	30	97.6	98.9	98.3
	31	60.0	38.7	48.9
	32	88.2	64.5	75.8
	33	95.3	98.9	97.2
	34*	24.7	36.6	30.9
	35	37.6	84.9	62.4
	36*	58.8	64.5	61.8

\* indicates a common question

(right and wrong) contingency table (Nie, et al., 1975). None of the 12 common questions were answered significantly differently by form of SATT (see Appendix L, Table L.1).

The identically numbered non-common question pairs will now be treated. Table L.2 in Appendix L lists these non-common question pairs together with their associated chi-square values. Of the 24 pairs of non-common questions 12 showed no significant differences (at the .05 level). Of the remaining 12, one pair proved significant at the .05 level, one at the .01 level, and 10 at the .001 level. Of these 12 significantly different question pairs, seven favoured Form A and five favoured Form B. Furthermore, the significantly different questions appeared to be reasonably evenly distributed over the three teaching levels (see Table L.3).

While the large number of significantly different pairs of questions could give cause for concern the fact that they were evenly distributed over both form and teaching level meant that it seemed reasonable to report the results of SATT as single test and sub-test scores (rather than distinguishing between Forms A and B). Indeed a comparison of overall Form A performance to that of Form B proved non-significant ( $t = -0.82$ , ns).

#### 5.3.2 Results on SATT

Table 5.2 also presents the pooled (from Form A and Form B) percentage correct for each pair of identically numbered questions, i.e. questions dealing with the same theme.

The mean SATT score for teachers (N=178) was 26.88

(maximum possible score = 36) with a standard deviation of 4.20. The median score was 27. Figure 5.1 is a frequency histogram of SATT scores which ranged from 14 (frequency 1) to 36 (frequency 2). The percentage of teachers who scored less than 50% correct was 2.2% (4/178). The percentage who scored less than 75% correct was 44.4% (79/178).

### 5.3.3 Results on SATT Subtest

One of the aims of this research is to describe teacher competence with the Spatial Awareness strand of the Primary Mathematics Guidelines. From the review of earlier studies however, it was apparent that such a description when based on overall test performances only was not as informative as one based on subtests appropriate to level of teaching. The present project was designed to allow for such a possibility. The SATT, designed to cover the K-6 grade range, contained three subtests corresponding to the three teaching levels of the Guidelines, viz. Infant, Middle Primary, Upper Primary. In addition, provision was made in the accompanying questionnaire for teachers to indicate which of these was their main level of teaching. Teacher performance on the SATT subtest relevant to their main level of teaching is now examined.

#### 5.3.3.1 Infant Teachers and the Infant Subtest

On the Infant subtest Infant teachers performed significantly [ $F(2,167)=5.70$ ,  $p<.01$ ] below the other teachers in the sample (Table 5.3).

Figure 5.1

Frequency Histogram of Teacher SATT Scores  
(N = 178)

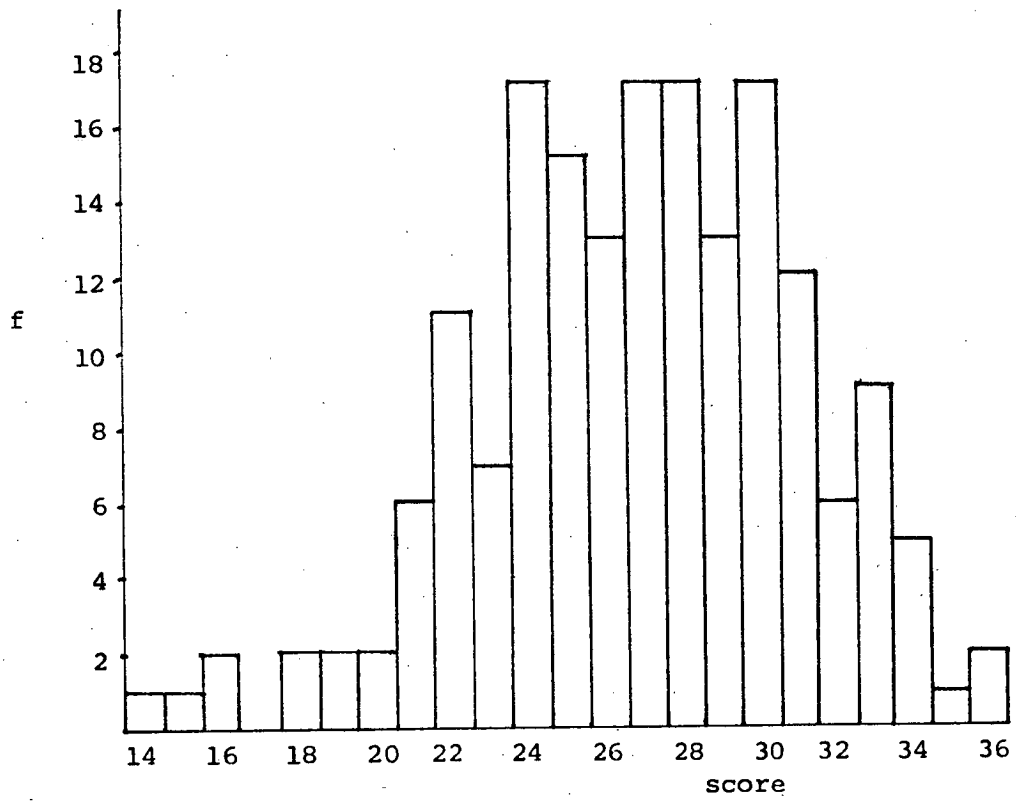


Table 5.3

Teacher Scores on the Infant Subtest

	Teachers		
	Infant	Middle Primary	Upper Primary
N	82	34	52
$\bar{x}$	8.79	9.59	9.59
s.d.	1.65	1.33	1.73



Figure 5.2 is a frequency histogram of Infant subtest scores for Infant teachers. The distribution was markedly non-normal; its kurtosis was -0.83. The percentage of Infant teachers who scored less than 50% correct (i.e. less than 6 out of 12) was 3.7% (3/82). The percentage who scored less than 75% (i.e., less than 9 out of 12) was 46.3% (38/82).

Infant teacher percentage correct on each of the Infant subtest questions is given in Table L.4. The percentage correct on Form A varied from 30% (q. 12) to 100% (q. 2). On Form B the percentage correct varied from 23.8% (q. 12) to 100% (qq. 2 and 4). Comment on these percentages and on the errors on the most difficult questions will be left until Section 5.11.

#### 5.3.3.2 Middle Primary Teachers and the Middle Primary Subtest

The difference between Middle Primary teachers and other teachers on the Middle Primary subtest was significant [ $F(2,167)=4.40$ ,  $p<.05$ ] (Table 5.4).

A frequency histogram of Middle Primary teacher performance on Middle Primary questions is given in Figure 5.3. The distribution was markedly non-normal and had a skewness of -0.78. No Middle Primary teachers scored less than 50% (i.e., less than 6 out of 12) on the Middle Primary subtest. Twenty six percent (7/34) scored less than 75% (i.e., less than 9 out of 12).

The percentage of Middle Primary teachers correct on each of the Middle Primary subtest questions is given in Table

Figure 5.2

Frequency Histogram of Infant Teacher Scores on the Infant  
Subtest  
(N = 82)

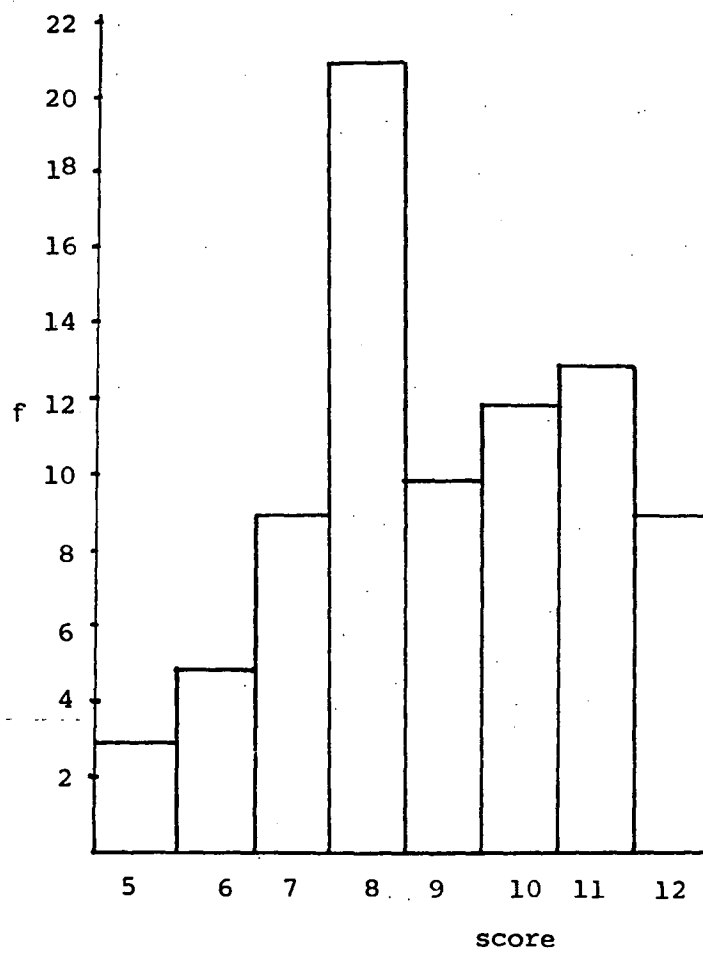


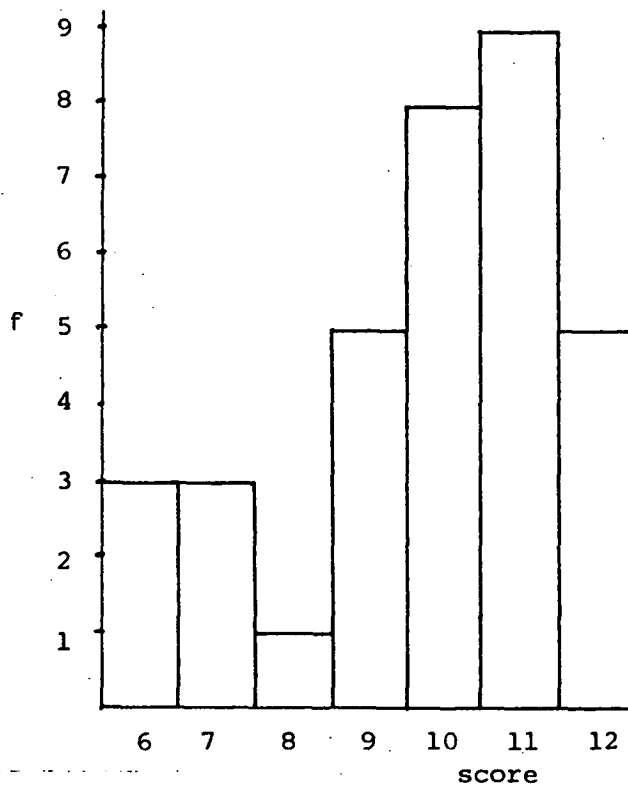
Table 5.4

Teacher Scores on the Middle Primary Subtest

	Teachers		
	Infant	Middle Primary	Upper Primary
N	82	34	52
$\bar{x}$	8.99	9.74	9.10
s.d.	1.91	1.83	1.58

Figure 5.3

Frequency Histogram of Middle Primary Teacher Scores on the  
Middle Primary Subtest  
(N = 34)



L.5. The percentage correct on Form A varied from 52.9% (qq. 14 and 22) to 100% (qq. 16, 18 and 19). On Form B the percentage correct varied from 64.7% (qq. 13, 14 and 24) to 100% (qq. 20 and 23). Comment on these percentages and on the errors on the most difficult questions will be left until Section 5.11.

#### 5.3.3.3 Upper Primary Teachers and the Upper Primary Subtest

On the Upper Primary subtest Upper Primary teachers did significantly better [ $F(2,167)=11.81$ ,  $p<.001$ ] than the other teachers (Table 5.5).

Figure 5.4 is a frequency histogram of Upper Primary teacher scores on the Upper Primary subtest. No Upper Primary teachers scored less than 50% correct (i.e., less than 6 out of 12) on the Upper Primary subtest. However, 34.6% (18/52) scored less than 75% correct (i.e., less than 9 out of 12).

The percentage of Upper Primary teachers correct on each of the Upper Primary subtest questions is given in Table L.6. There were five questions answered 100% correctly. The percentage correct on Form A varied from 45.5% (qq. 25, 34 and 35) to 100% (qq. 26, 32 and 33). On Form B the percentage correct varied from 46.7% (qq. 31 and 34) to 100% (qq. 30 and 33). Comment on the errors on the most difficult questions will be left until Section 5.11.

### 5.4 Teacher Performance on MST1

A brief description of teacher performance ( $N=178$ ) on MST1 is now given. The mean score (maximum score = 24) was 19.68 with a standard deviation of 3.0. The KR-20 reliability

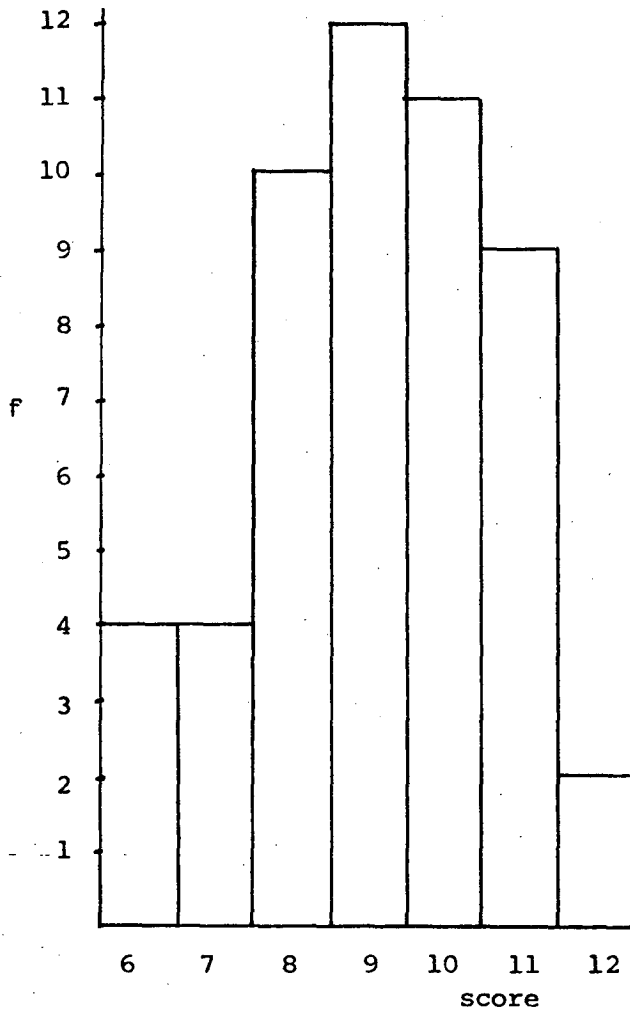
Table 5.5

Teacher Scores on the Upper Primary Subtest

	Teachers		
	Infant	Middle Primary	Upper Primary
N	82	34	52
$\bar{x}$	7.52	8.41	9.10
s.d.	1.84	1.94	1.58

Figure 5.4

Frequency Histogram of Upper Primary Teacher Scores on the  
Upper Primary Subtest  
(N = 52)



coefficient for MST1 seemed reasonable at .6405. A frequency histogram of scores is given in Figure 5.5.

As much of the analysis in the present project is based on grouping by "level of teaching" these subsample means and standard deviations were calculated (see Table 5.6). Analysis of variance showed that by score on MST1 the three subsample groups were not significantly different ( $F(2,165) = 1.17$ , ns).

#### 5.5 Attributes of the Student Teacher Sample

Students in all six of the 4th year, that is final year, courses in Infant and Primary Method in the two Tasmanian teacher training institutions were tested on Spatial Awareness competence. The groups, the numbers of enrolments, and the numbers and percentages tested are given in Table 5.7.

The course with the lowest percentage tested was the TCAE B.Ed. Primary Method course with 67%. This low percentage was probably due to those students being on practicum at the time. The U of T Dip. Ed. Infant Method course also only managed a relatively low percentage of student teachers tested. However, most of the absentees were parents; testing occurred on a school holiday and it seems that they thus needed to stay home.

Testing at the TCAE occurred in March, 1982 and at the U of T in June, 1982. Summary data on the number enrolled and the number tested by type of student teacher training are given in Table 5.8. Altogether, 193 student teachers were



Figure 5.5

Frequency Histogram of Teacher MST1 Scores  
(N = 178)

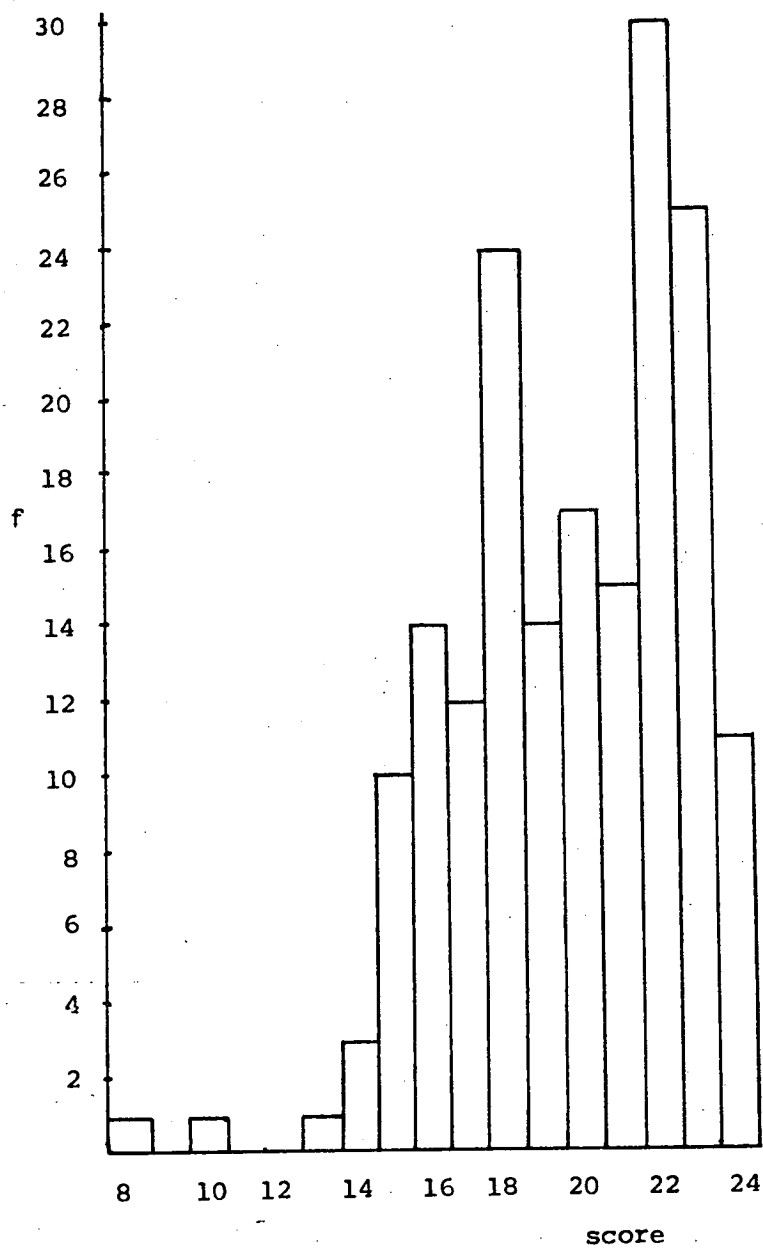


Table 5.6

Teacher MST1 Scores

	Teachers		
	Infant	Middle Primary	Upper Primary
N	82	34	52
$\bar{x}$	19.31	19.68	20.14
s.d.	3.04	3.32	2.92

Table 5.7

Data on 4th Year Courses in Infant and Primary Method

Type of Course			Number Enrolled	Number Tested	% Tested
TCAE	B.Ed.	Infant Method	38	36	95
TCAE	B.Ed.	Primary Method	30	20	67
U of T	B.Ed.	Infant Method	60	54	90
U of T	B.Ed.	Primary Method	38	35	92
U of T	Dip.Ed.	Infant Method	30	22	73
U of T	Dip.Ed.	Primary Method	33	26	79
Sum			229	193	84

Table 5.8

Data on Student Teacher Percentage Tested by Level of Training

	Number Enrolled	Number Tested	% Tested
Infant	128	112	87.50
Primary	101	81	80.19
Sum	229	193	84.27

tested. There were few males (only 14.5%). The ages of the sample varied from 19 to over 30. Most had a background of only Grade 10 mathematics (70%) and only 26.5% had at least one year of Grades 11 and 12 (i.e., non-compulsory) mathematics.

### 5.6 Student Teacher Performance on SATT

#### 5.6.1 Individual Items and SATT Form A and SATT Form B

The student teacher data and analyses which follow parallel those given for teachers in Section 5.3. The percentage correct for each question on each of the forms by the student teacher sample is given in Table 5.9. In Form A the percentage of correct answers varied from 12.6% (q. 35) to 100% (q. 2). In Form B the percentage correct varied from 14.3% (qq. 12 and 31) to 100% (qq. 2 and 20). Among the 12 common questions the percentage correct varied from 14.5% (q. 12) to 100% (q. 2). KR-20 test and subtest reliability coefficients for the student teacher sample is given in Appendix M.

Recall that in Section 5.3.1 it was found that SATT Form A and SATT Form B could be pooled for the teacher sample. Similar analyses are repeated for the student teacher sample. Table L.7 is a list of the 12 common questions and their corrected chi-square values. None differed significantly (at the .05 level) on the proportion of correct answers by form of SATT.

Table L.8 lists the 24 non-common questions and their corrected chi-square values. Table L.9 shows the distribution

Table 5.9

Percentage of Student Teachers Correct on each question of SATI  
Form A and Form B.

Subtest	Question Number	SATI A (N = 95)	SATI B (N = 98)	SATI (N = 193)
Infant Subtest	1	94.7	85.7	90.2
	2*	100.0	100.0	100.0
	3*	74.7	80.6	77.7
	4	14.7	93.9	54.9
	5	44.2	78.6	61.7
	6	47.4	92.9	70.5
	7*	43.2	37.8	40.4
	8	90.5	95.9	93.3
	9	63.2	62.2	62.7
	10	51.6	54.1	52.8
	11	91.6	94.9	93.3
	12*	14.7	14.3	14.5
Primary Subtest	13*	44.2	48.0	46.1
	14	37.9	61.2	49.7
	15	63.2	62.2	62.7
	16	98.9	39.8	68.9
	17*	67.4	61.2	64.2
	18	90.5	93.9	92.2
	19	94.7	23.5	58.5
	20	54.7	100.0	77.7
	21*	82.1	76.5	79.3
	22*	71.6	63.3	67.4
	23	89.5	87.8	88.6
	24	67.4	38.8	52.8
	25*	29.5	38.8	34.2
	26	61.1	74.5	67.9
	27	50.5	39.8	45.1
	28	69.5	67.3	68.4
	29*	66.3	76.5	71.5
	30	95.8	94.9	95.3
	31	35.8	14.3	24.9
	32	75.8	65.3	70.5
	33	83.2	86.7	85.0
	34*	22.1	28.6	25.4
	35	12.6	76.5	45.1
	36*	32.6	24.5	28.5

\* indicates a common question

of the ten questions which yielded significant differences by form of SATT and teaching level. As these significant questions would appear to be reasonably evenly distributed between the levels of teaching and forms of SATT it seemed reasonable to combine SATT Form A and Form B for student teachers. Indeed, a t-test comparing scores on the two SATT forms proved nonsignificant ( $t = -1.51$ , ns).

#### 5.6.2 Results on SATT

The percentages correct for combined questions on SATT for student teachers are also given in Table 5.9. The mean SATT score for student teachers ( $N=193$ ) was 22.82 with a standard deviation of 4.94. Modal score was 22 and the median score 22.73. A frequency histogram of SATT scores is given in Figure 5.6. The percentage of student teachers who scored less than 50% correct was 11.4% (22/193). The percentage who scored less than 75% was 78.76% (152/193).

#### 5.6.3 Results on SATT Subtests

The teacher sample was divided into three subsamples according to their level of teaching. A similar three-fold division of the student teacher sample was not possible as their training programmes recognized only two levels, viz. Infant (K-2) or Primary (3-6). Therefore, only two subsample analyses, Infant and Primary, could be reported. The Infant subtest contained questions 1 to 12 inclusive and the Primary subtest contained questions 13 to 36 inclusive.

##### 5.6.3.1 Infant Student Teachers and the Infant Subtest

Table 5.10 gives student teacher performances on the

Figure 5.6

Frequency Histogram of Student Teacher SATT Scores  
(N = 193)

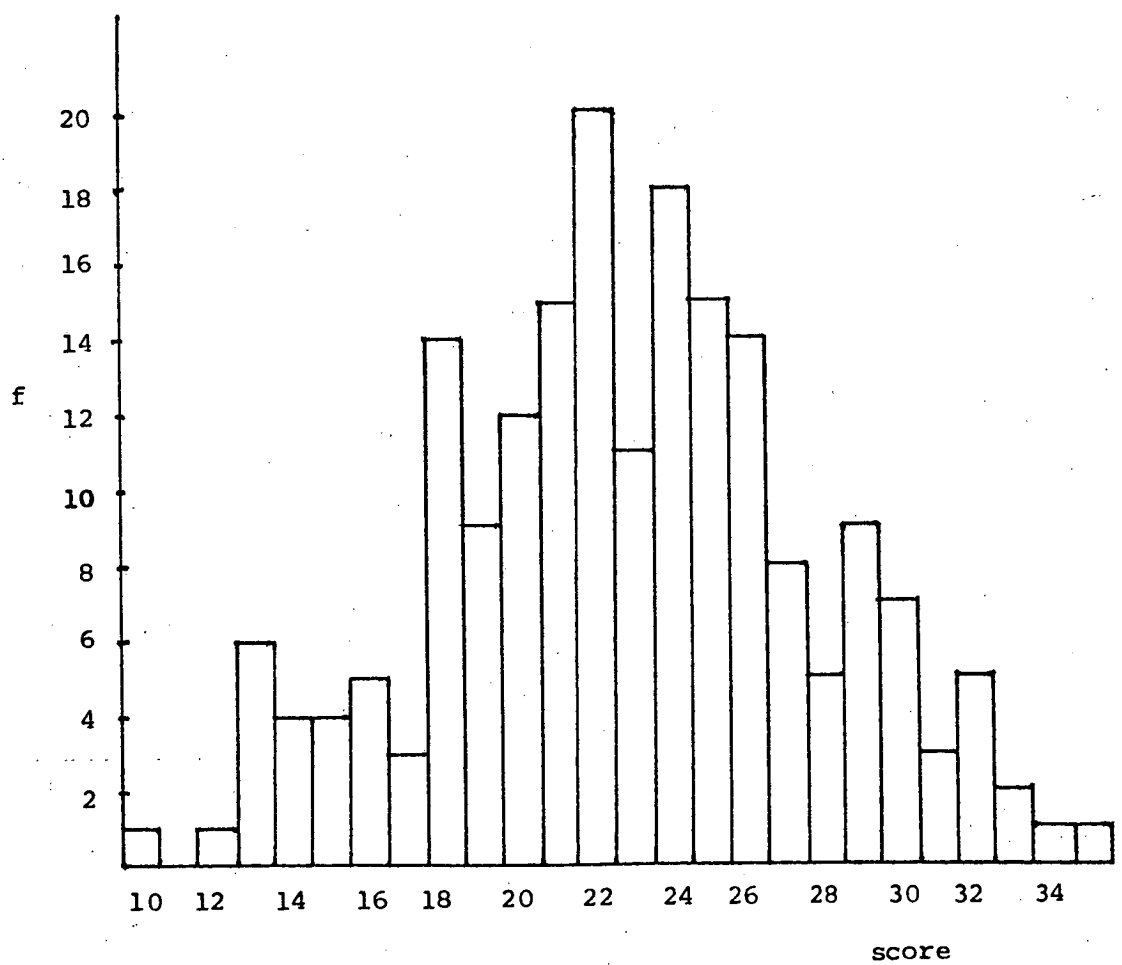




Table 5.10

Student Teacher Scores on the Infant Subtest

	Student Teachers	
	Infant	Primary
N	112	81
$\bar{x}$	7.91	8.41
s.d.	1.97	1.95

Infant subtest. The difference between Infant student teachers and Primary student teachers was non-significant [ $t(191) = 1.73$ ,  $p < .10$ ].

A frequency histogram of Infant student teacher scores is given in Figure 5.7. The percentage of Infant student teachers who scored less than 50% correct (i.e., less than 6 out of 12) was 14.3% (16/112) while the percentage who scored less than 75% correct (i.e., less than 9 out of 12) was 77.7% (87/112).

Infant student teacher percentages correct on each of the Infant subtest questions are given in Table L.10. The percentage correct on both Form A and Form B varied from 10.7% (q. 12) to 100% (q. 2). The errors on the most difficult questions will be discussed in Section 5.11.

The research hypotheses relating to the student teacher sample will now be tested (see Section 3.2.2). The first of these was SHol(i). The SATT performances of the students in the three Infant courses (see Table 5.11) were subjected to analysis of variance. This analysis showed that although the U of T Dip.Ed. students seem to perform at a lower level, the differences between the three courses were, however, non-significant ( $F(2,109) = 2.738$ ,  $p < .10$ ) in line with SHol(i).

The second hypothesis tested was SHol(ii). The SATT Infant subtest scores for the three courses (see Table 5.12) were subjected to analysis of variance, and again no significant differences were found ( $F(2,109) = 2.014$ ,  $p < .25$ ).

Figure 5.7

Frequency Histogram of Infant Student Teacher Scores on the  
Infant Subtest  
(N = 112)

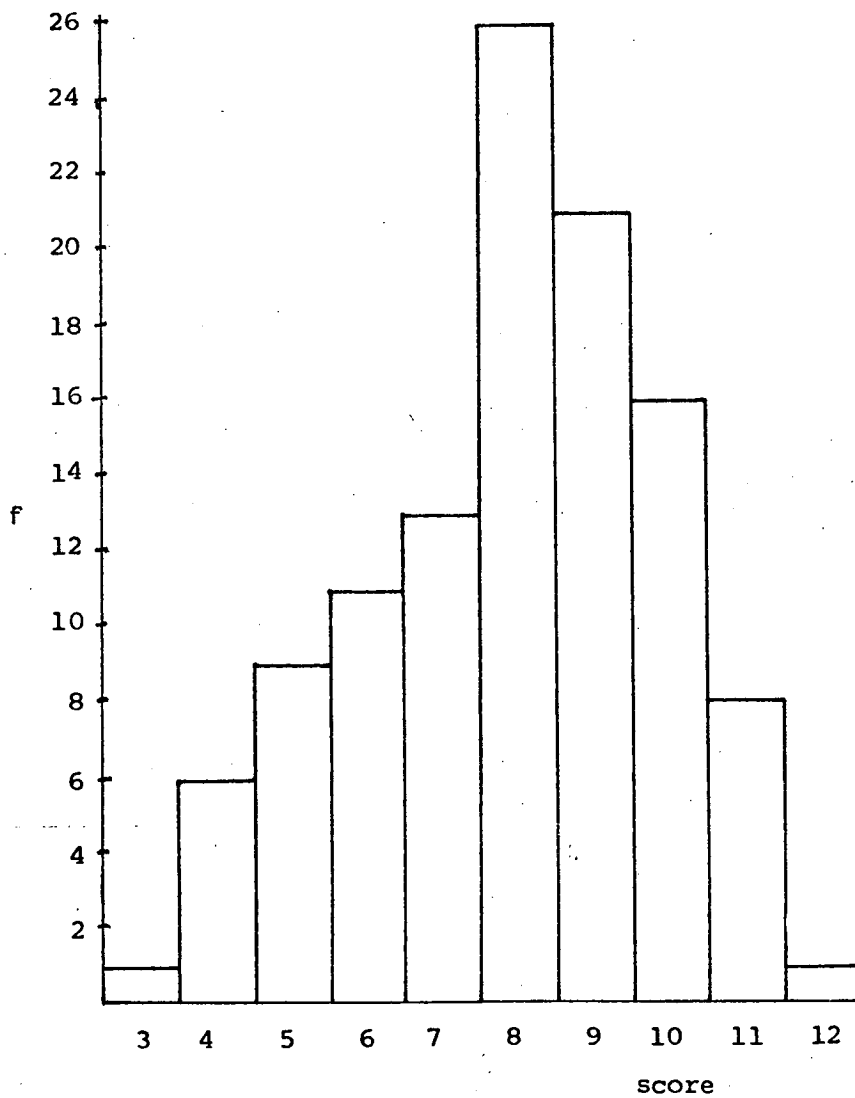


Table 5.11

Infant Student Teacher SATT Scores

	Infant Student Teacher Course		
	TCAE	U of T Dip.Ed.	U of T B.Ed.
N	36	22	34
$\bar{x}$	22.33	19.91	22.56
s.d.	4.88	5.10	4.22

Table 5.12

## Infant Student Teacher Infant Subtest Scores

	Infant Student Teacher Course		
	TCAE	U of T Dip.Ed.	U of T B.Ed.
N	36	22	54
$\bar{x}$	7.97	7.18	8.17
s.d.	2.12	2.17	1.73

These nonsignificant differences might be considered surprising since the teacher training backgrounds of the groups were quite different. Whereas both B.Ed. groups were in their 4th year of teacher training the Dip. Ed. group was, strictly speaking, in its first year. Both B.Ed. groups had had three years of compulsory mathematics education studies, and while the majority of this time was spent on Number, some was usually spent on Spatial Awareness. In contrast, the U of T Infant Dip. Ed. course seems not to contain any explicit provision for Spatial Awareness instruction. This result is discussed further in Chapter 7.

#### 5.6.3.2 Primary Student Teachers and the Primary Subtest

Table 5.13 gives student teacher performances on the Primary subtest. The Primary student teachers did significantly better [ $t(191)=2.97, p<.01$ ]. A frequency histogram of Primary student teacher scores on the Primary subtest is given in Figure 5.8. The percentage of Primary student teachers who scored less than 50% correct (i.e., less than 12 out of 24) and less than 75% correct (i.e., less than 18 out of 24) was 12.34% (10/81) and 66.67% (54/81) respectively.

The percentage of Primary student teachers correct on each of the Primary subtest questions is given in Table L.11. The percentage correct on Form A varied from 7.7% (q. 35) to 97.4% (qq. 16 and 19). On Form B the percentage correct varied from 14.3% (q. 31) to 100% (q. 18). The errors on the most difficult questions are briefly discussed in Section 5.11.

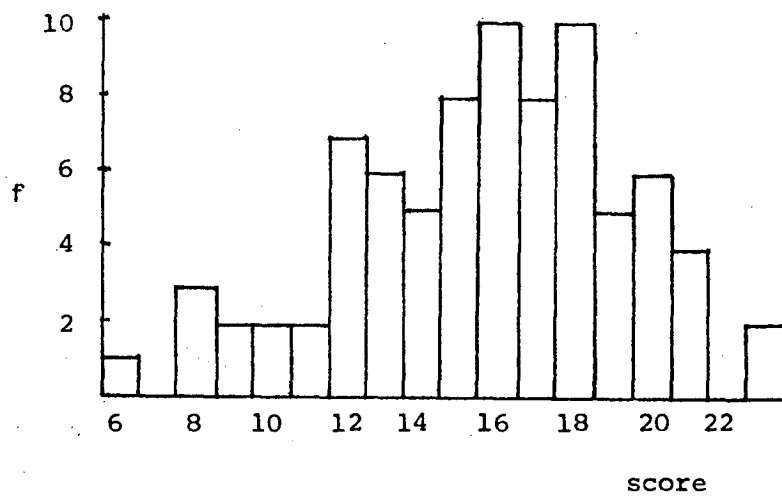
Table 5.13

Student Teacher Scores on the Primary Subtest

	Student Teachers	
	Infant	Primary
N	112	81
$\bar{x}$	14.05	15.59
s.d.	3.45	3.67

Figure 5.8

Frequency Histogram of Primary Student Teacher Scores on the  
Primary Subtest  
(N = 81)





There were also two research hypotheses dealing with Primary student teachers. The first was  $SHo2(i)$ . The SATT scores of the three Primary courses are given in Table 5.14. The differences in scores between the three groups proved nonsignificant, ( $F(2,78) < 1$ ), in line with  $SHo2(i)$ .

The next hypothesis was  $SHo2(ii)$ . Data on the Primary subtest scores are given in Table 5.15. Again, no significant differences between the groups on their Primary subtest scores were found ( $F(2,78) = 1.47$ ,  $p < .25$ ).

These nonsignificant differences for Primary student teachers could also be thought surprising if one recalls the aforementioned differences in teacher training background between the B.Ed. groups and the Dip. Ed. group. It seems that three years of student teacher training, the difference between the B.Ed. and the Dip. Ed. programmes, might make little difference to Spatial Awareness competence.

#### 5.7 Student Teacher Performance on MST1

A brief description of student teacher performance on MST1 is now given. The mean score (maximum score = 24) was 17.06 with a standard deviation of 3.87. The KR-20 reliability coefficient for MST1 was good at .7424. A frequency histogram of scores is given in Figure 5.9.

Performances by course of study are given in Table 5.16. Analysis of variance showed that by score on MST1 the six groups were not significantly different ( $F(5,187) = 1.56$ ,  $p < .25$ ).

Table 5.14

## Primary Student Teacher SATT Scores

	Primary Student Teacher Course		
	TCAE	U of T Dip.Ed.	U of T B.Ed.
N	20	26	35
$\bar{x}$	25.15	23.23	23.91
s.d.	4.23	5.41	5.25

Table 5.15

Primary Student Teacher Primary Subtest Scores

	Primary Student Teacher Course		
	TCAE	U of T Dip.Ed.	U of T B.Ed.
N	20	28	35
$\bar{x}$	16.70	14.85	15.51
s.d.	3.06	4.12	3.59

Figure 5.9

Frequency Histogram of Student Teacher MST1 Scores  
(N = 195)

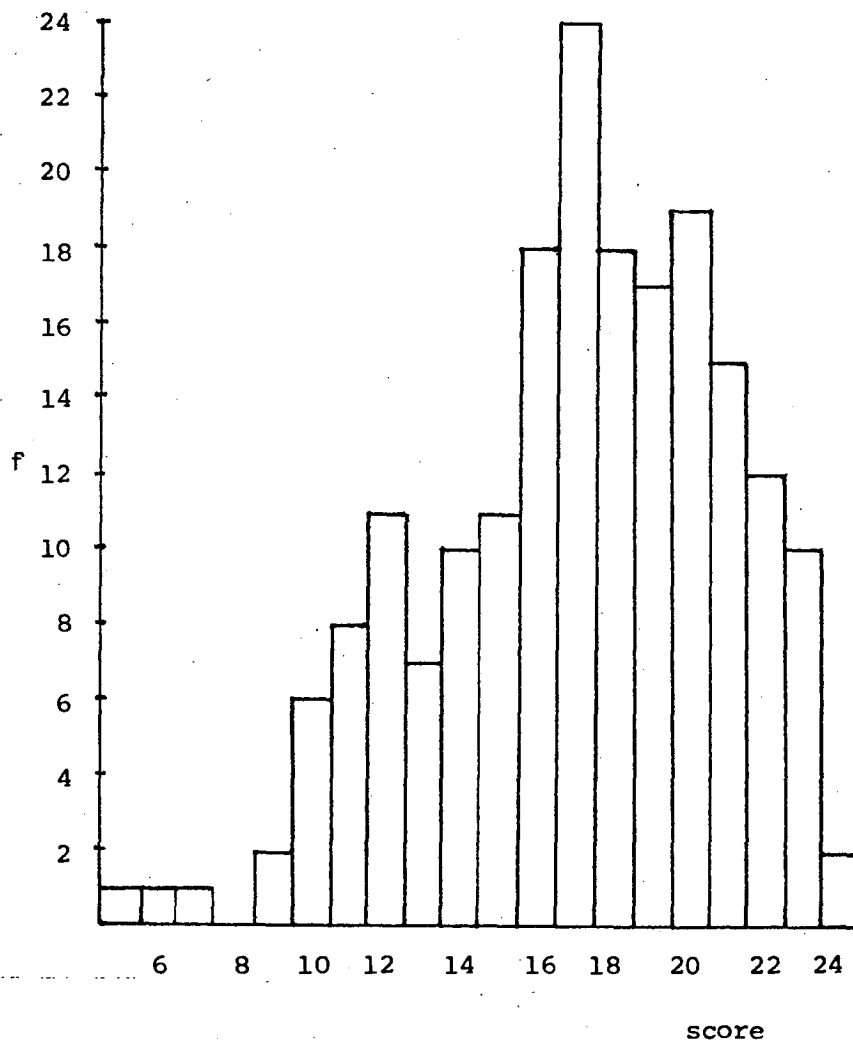


Figure 5.9

Frequency Histogram of Student Teacher MST1 Scores  
(N = 195)

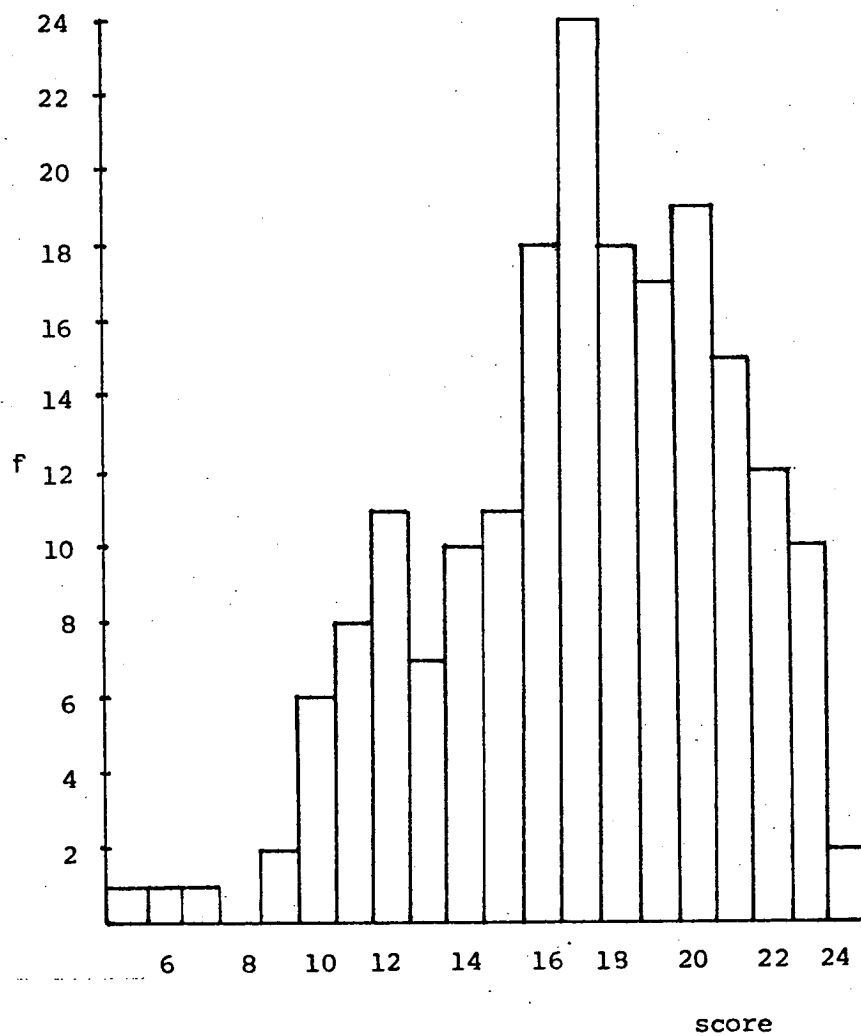


Table 5.16

## Student Teacher MST1 Scores

	Student Teacher Course					
	TCAE Infant	TCAE Primary	U of T Dip. Infant	U of T Dip. Primary	U of T B.Ed. Infant	U of T B.Ed. Primary
N	36	20	22	26	54	35
$\bar{x}$	17.06	18.15	15.55	16.69	17.78	16.54
s.d.	3.82	3.62	3.75	4.47	3.04	4.57

## 5.8 A Summary of Teacher and Student Teacher

### Comments on SATT

#### 5.8.1 Introduction

Both samples were invited to make written comments on SATT or on individual items in the space provided at the back of the test booklet. Their detailed comments are reproduced in Appendix K, along with a key for deciphering the code which identifies each comment.

This section is divided into teacher comments on SATT and student teacher comments on SATT. In each, a summary is given of the number and type of comment. In some cases minor liberties have been taken with spelling and syntax.

#### 5.8.2 Teacher Comments on SATT

The number and percentage of comments at the different teaching levels are given in Table 5.17. At each of the three levels, more than 25% of respondents chose to comment.

Attitude towards the test was one of the most conspicuous features of the comments. It ranged from 'Good Stuff!!' (TUB001) and '... would you mind sending a copy of each test ... to use with my class ...' (TUA009) to 'As a Music teacher I see little value in tests such as these!' (TMB012). Another feature was an indication of the origin of their spatial knowledge. Many teachers found themselves recalling knowledge apparently learnt and last used in High school.

The common question 34 on parabolae and parabolic motion was the question which caused the most concern, even among Upper Primary teachers.

Table 5.17

## Teacher Comments on SATT

Level of Teaching	Number of Respondents	Number of Comments	% of Comments
Infant	82	21	25.6
Middle Primary	34	10	29.4
Upper Primary	52	14	26.9
Missing or Ambiguous	10	--	0
Total	178	45	25.3



Some teachers commented that they had had their Spatial Awareness interest kindled or rekindled, e.g. TIA030, TIB019, TMB003, TMB004, TUA009 and TUB007.

There were also teachers who did not appear to realise that the topics covered were ones which they should have known about and been teaching, e.g. "[In grades 1, 2 and 3] we deal mainly with basic pure number" (TIA039), TMA004 and TMB008.

#### 5.8.3 Student Teacher Comments on SATT

The number and percentage of comments at each of the teacher training levels is given in Table 5.18. The percentage response rates of teachers and student teachers for the different levels of teaching were fairly similar.

Student teacher attitude towards the test ranged from "enjoyment" (SNI007) and "really interesting" (SUBp016) to the ambiguous "In other words we know enough about Maths to educate young children - so what is all the panic about?" (SNI013).

Some Infant student teachers felt that they had to draw on high school knowledge, paralleling the sentiment of many of the Infant teachers. There were quite a few comments dealing with the seeming over-dependence on definitions, the knowledge needed, or formulae, e.g. SUBpA004, SUDpA012, SUDpB007 and SNI010. This could suggest that student teachers, even if they were going to present their pupils with appropriate Spatial Awareness situations, were going to pass over the opportunity to use the correct term(s) or

Table 5.18

## Student Teacher Comments on SATT

Level of Student Teaching	Number of Respondents	Number of Comments	% of Comments
Infant	112	27	24.1
Primary	81	29	35.8
Total	193	56	29.0%

neglect some of the ways of consolidating, varying or extending the topic or activity.

Two other student teacher comments on Spatial Awareness teaching in schools were noteworthy: "Little spatial awareness work is being done in schools and it is not encouraged a great deal." (SNpb004); and "Reference to some particular activities, e.g. tessellations, would depend very much on what particular schools you had been in, as not all schools would have these activities." (SNiB011). These comments suggest three less-than-ideal situations. First, it could be that little explicit Spatial Awareness work is being done in at least some Tasmanian Infant and Primary schools. Second, it could be that there is uneven quantity and quality of Spatial Awareness work within and between schools. Third, it could be that in at least one of the six teacher training courses in Tasmania the course organisers are relying on schools rather than the course of study itself to provide learning in a part of the mathematics syllabus.

There were no questions which drew more than a few comments.

#### 5.9 Comparisons Between Trial Survey Teacher and Main Survey Teachers: SATT and MST1

##### 5.9.1 SATT

The results of teachers from the trial survey were compared with those of teachers from the main survey. Recall that the trial sample was spread over the K-6 Grade range, and that testing was done under examination conditions in the

presence of the author.

Because of the grossly unequal sample sizes, 38 and 178, the non-parametric Mann-Whitney U test was used. Note that since one question in each form was changed as a result of the trial survey, the trial versus main comparison employed only SATT questions common to both. The  $p$ -level associated with the  $z$ -score in Table 5.19 ( $<.001$  level) gives an indication of the likelihood that the two samples came from the same population and observed the same test conditions.

Such a low  $p$ -level deserves brief comment. There was no obvious reason for thinking that the Spatial Awareness competence of the 38 teachers tested in the trial survey was extraordinarily deficient. Therefore one is led to the conclusion that the request to teachers in the main survey to observe similar conditions to those experienced by teachers in the trial survey was perhaps not heeded. This point will be returned to in Chapter 7.

#### 5.9.2 MST1

Data from both the trial and postal survey samples for MST1 are given in Table 5.20. Again, because of the grossly unequal sample sizes, 35 and 178, the non-parametric Mann-Whitney U test was used to test the assumption that the two sample distributions came from the same population and observed the same test conditions.

The low  $p$ -level in Table 5.20 ( $.01$  level) suggests that the postal survey teachers again might not have acceded to the request for examination conditions while doing MST1. This will also be discussed in Chapter 7.

Table 5.19

Teacher Performance on SATT  
(Maximum score = 35)

	Trial Survey	Main Survey	z-score
N	38	178	-4.0162***
Mean rank	71.63	116.37	

\*\*\*  $\underline{p} < .001$

Table 5.20

Teacher Performance on MST1

	Trial Survey	Main Survey	z-score
N	35	178	-3.2294**
Mean rank	76.43	113.01	

\*\*  $\underline{p} < .01$

## 5.10 Comparisons between Teachers and

### Student Teachers: SATT and MST1

#### 5.10.1 Introduction

In Sections 5.3 and 5.6 teacher and student teacher performance, respectively, on SATT was described. In this Section the performances of these two samples on SATT score, SATT subtest score, and MST1 score are compared. However, from Section 5.9 above it would seem that any interpretations of such comparisons might be confounded by differences in the test settings, viz. postal survey versus examination conditions. Before assessing any performance differences between main survey teachers and student teachers, it was therefore decided to first compare the performances of teachers and students attained under similar test conditions. Such a comparison was possible between trial survey teachers and student teachers.

#### 5.10.2 Trial Survey Teachers and Student Teachers: SATT and MST1

Because of the difference in sample size between trial teachers (N=38) and student teachers (N=193) it was decided to use the non-parametric Mann-Whitney U test on common SATT scores. The maximum possible score for both samples was 35.

From Table 5.21 it can be seen that under similar test conditions teachers and students teachers performed similarly.

The MST1 scores of the trial teacher sample and the student teacher sample were also compared. Again the large

Table 5.21

Sample Performance under similar Test Conditions: the 35  
Common SATT Questions

	Trial Teacher Sample	Student Teacher Sample	z-score
N	38	193	-0.33 (n.s.)
Mean rank	119.24	115.36	



difference in sample size,  $N=35$  and  $N=193$ , meant that the non-parametric Mann-Whitney U test was the appropriate statistical test to use. Table 5.22 indicates that the difference between MST1 scores was also nonsignificant.

#### 5.10.3 Main Survey Teachers and Student Teachers: SATT

With the above discussed potential confounding in mind, hypotheses T&SHo3 to T&SHo5 were tested.

##### 5.10.3.1 SATT Score

Table 5.23 is a summary of the comparison of main survey teacher and student teacher SATT scores. The difference between the scores was significant, and therefore, T&SHo3 was rejected. The significant difference would seem due to either the confounding variation in test setting, or real differences in competence. Taking the results of Table 5.21 into account it seems reasonable that it might be almost wholly attributable to test setting.

##### 5.10.3.2 SATT Subtest Score

As a complement to sections 5.3 and 5.4 comparisons between teachers and student teachers on SATT subtest scores were performed. However, since student teachers were trained at only Infant or Primary, it was necessary to combine the teacher Middle Primary and Upper Primary subsamples into a teacher Primary subsample. The  $p$ -levels associated with the differences in Infant and Primary subtest scores were calculated using the Mann-Whitney U test (see Tables 5.24 and 5.25).

Table 5.22

Sample Performance under similar Test Conditions: MST1

	Trial Teacher Sample	Student Teacher Sample	z-score
N	35	193	-0.25 (n.s.)
Mean rank	117.04	114.04	

Table 5.23

Main Survey Teacher and Student Teacher SATT Scores

	Main Survey Teachers	Student Teachers	t-value (pooled variance)
N	178	193	8.50***
$\bar{x}$	26.88	22.82	
s.d.	4.20	4.94	

\*\*\*  $p < .001$

Table 5.24

Main Survey Infant Teacher and Infant Student Teacher Infant  
Subtest Scores

	Infant Teachers	Infant Student Teachers	z-score
N	82	112	3.0914**
Mean rank	111.82	87.00	

\*\*  $p < .01$

Table 5.25

Main Survey Primary Teacher and Primary Student Teacher  
Primary Subtest Scores

	Primary Teachers	Primary Student Teachers	z-score
N	86	81	5.5598***
Mean rank	104.11	62.65	

\*\*\*  $p < .001$

The difference between the Infant subsamples was significant, so T&SHo4 was rejected. Similarly, that between the Primary subsamples was also, and thus T&SHo5 was rejected. Therefore, the significant difference previously found on overall SATT score also manifested itself on the Infant and Primary subtests for the Infant and Primary subsamples, respectively. However, given the results of comparisons between trial survey teachers and main survey teachers one is again led to the real confounding possibility that these differences in SATT subtest scores are almost wholly attributable to test setting variations.

#### 5.10.3.3 SATT Items

It was originally thought that a comparison of the proportions correct on individual items of the appropriate subtest for each of the Infant and Primary subsamples could have given useful information. However the significant differences in the performance of the subsamples on both subtests meant that, almost certainly, each question would also load heavily in favour of the Infant teacher and Primary teacher subsamples, respectively. Therefore, this analysis was not attempted.

#### 5.10.4 Main Survey Teachers and Student Teachers: MST1

To complement the picture of comparisons between teachers and student teachers, their MST1 scores were also compared (see Table 5.26). The difference between the MST1 scores of the samples was also significant (at the .001 level). Again, this finding is at least partially attributable to the test setting confound.

Table 5.26

Teacher and Student Teacher MST1 Scores

	Teachers	Student Teachers	t-value (pooled variance)
N	178	193	7.24***
$\bar{x}$	19.68	17.06	
s.d.	3.02	3.87	

\*\*\*  $p < .001$

#### 5.10.5 Summary of Teacher and Student Teacher Comparisons

On the basis of the findings in this section it is not possible to make interpretative comment on the performance of teachers versus student teachers at any level of test, subtest or item performance. However, these findings do not invalidate the many comparisons that have been made within the same sample of either teachers or student teachers as their test conditions were consistent.



## 5.11 Some Errors of Teachers and Student Teachers

### 5.11.1 Introduction

It would seem that of the reviewed studies which looked at teacher mathematical competence none have reported an analysis of errors. Such is unfortunate in that their emphases on global relationships and total scores would lessen the utility of these studies for inservice and pre-service teacher training. For example, knowledge of a correlation coefficient relating mathematics score to the taking of optional mathematics courses in high school is not obviously as directly useful from a training viewpoint as a knowledge that many Infant teachers and student teachers apparently confuse 'prism' with 'pyramid'. This latter information might suggest a short, once-off concrete exposure to different types of solids commonly used in the Infant school. It is not so obvious how a knowledge of a correlation coefficient could lead to such training suggestions.

For the present teacher samples the three most difficult SATT questions from each of Form A and Form B at each of the three teaching levels were chosen for comment. Similarly, for the two levels of student teachers, three questions from each of Form A and Form B were also chosen. As some of the most difficult questions were also free response, parts of Appendix F 'Notes on the Marking of the Free-Response Items in SATT' are here repeated when relevant.

### 5.11.2 The Errors of Teachers

An error analysis using all teachers was not performed since it was felt that such would not produce anything over and above separate analyses for each of the Infant, Middle Primary and Upper Primary subsamples.

#### 5.11.2.1 The Errors of Infant Teachers

The three most difficult questions for Infant teachers (see Table L.4) were (in order of difficulty) 12, 4 and 7, and 12, 7 and 10, from Forms A and B, respectively. As questions 12 and 7 were common, their responses have been pooled (see Table 5.27).

With question 12 it seems that many Infant teachers confused 'pyramid' with 'prism'; 27% thought that figure 5, a pyramid, was perhaps also a prism and so gave 'd' as their response. Those who gave 'a' as their response could have also confused 'prism' and 'pyramid' as '1' and '5' were the only solids sitting on an 'end' or 'bottom'.

In question 7 only approximately two-fifths of Infant teachers responded correctly. The rest were apparently unable to note the disjoint sets formed from 'thin' and 'thick'. Those who chose 'c' and 'd' showed some evidence of noting the disjoint nature of parts of the information in the question but they were still unable to arrive at the correct solution.

The next most difficult question in Form A for Infant teachers was question 4; only 35% correctly identified the four solids. The difficulty was largely due to leaving out

Table 5.27

Percentages for the Responses of Infant Teachers to the Infant  
Subtest Question Numbers 12 and 7  
(N = 82)

Choice	Question	
	Number 12	Number 7
a	18	39*
b	5	16
c	27*	27
d	27	17
e	18	0
No answer	5	1

\* indicates the correct response

or incorrectly naming solid number 4, the hexagonal prism. Those who incorrectly named it called it a sixahedron, a hexa?, a hexagonal sphere, a pentahedron, an octahedron, a hexagon, a rectangular hexagon, a hextroid and a rhombus. There were also several who called solid number 2 (the pyramid), a prism. Both errors indicated problems with terminology.

The third most difficult question for Infant teachers in Form B was question 10 (see Table 5.28). It can be seen that many Infant teachers thought that the regular hexagon, 'd', also did not completely cover a page when its shape is repeated (tessellated).

#### 5.11.2.2 The Errors of Middle Primary Teachers

The most difficult questions for Middle Primary teachers from the Middle Primary subtest were questions 22, 14 and 20, and 13, 14 and 24, from Forms A and B, respectively (see Table L.5).

The responses to question 22 of Form A are given in Table 5.29. These results indicated that of the types of transformations met in the Middle Primary 'reflection' was easily recognised whereas 'translation' was not nearly so easily recognised.

The responses to questions 14 and 20 of Form A have been combined in Table 5.30. With Form A question 14 there appeared to be confusion regarding 'axes of symmetry'. Choice 'd', the most popular incorrect choice, was surprising as it had five axes of symmetry. Perhaps the main reason for

Table 5.28

Percentages for the Responses of Infant Teachers to the Infant  
Subtest Form B, Question 10  
(N = 42)

Choice	Percentage
a	0
b	2
c	40*
d	21
e	10
No answer	5
c and d	26

\* indicates the correct response

Table 5.29

Percentages for the Responses of Middle Primary Teachers  
to the Middle Primary Subtest Form A, Question 22

Choice	Question	
	Number 22I	Number 22II
a	6	6
b	6	94*
c	59*	0
d	29	0

\* indicates the correct responses

Table 5.30

Percentages for the Responses of Middle Primary Teachers to the Middle Primary Subtest Form A, Questions 14 and 20, and Form B, Question 14  
(N = 17)

Choice	Question		
	Form A No. 14	Form A No. 20	Form B No. 14
a	53*	65*	0
b	6	0	65*
c	12	0	6
d	24	29	24
e	(not possible)	6	6
No answer	6	0	0

\* indicates the correct response

the incorrect responses was to mistake axis or axes of symmetry with area bisection. That is to say, the ease with which it is possible to draw a line through a shape which bisects the area becomes the criterion for whether or not the shape has an axis of symmetry. Therefore, although incorrect in this instance, this reasoning says that 'a' has an axis of symmetry so the answer is elsewhere.

The pattern of response in question 20 was essentially that they either got it correct or they opted for choice 'd'. Such would indicate that these error making subjects perhaps misunderstood that the squares each had side length 'r' or that no overlap was allowed. In order to allow four congruent squares inside a circle, choice 'd', each of the square sides must be considerably less than the length of the radius.

When marking Form B question 13 (answered correctly by 65% of Middle Primary teachers), it was difficult to decide how much latitude to allow for looseness of expression. For example, "Spaced parallel lines dividing a plane into congruent regions of similar shape." was adjudged incorrect, as the emphasis seemed to be on parallel lines rather than repeated pattern. On the other hand some possibly marginal written answers were accepted because the accompanying diagrams were exemplary. The answer "A series of square or angular shapes laid down so as to make a pattern." was barely thought to be sufficient but the accompanying drawing of octagons and squares made up for what the words left out. All answers without a diagram were marked incorrect. Only one Middle Primary teacher did not attempt an answer.



Question 14 of Form B was also one of the most difficult questions for Middle Primary teachers (see also Table 5.30). As with the responses to question 14 in Form A, teachers possibly confused quadrisection of area with four axes of symmetry and so selected 'd'.

Question 24 of Form B, also answered correctly by 65% of Middle Primary teachers, was also a free response item. Here subjects were to construct a grid and draw a triangle with area 3 square units. Of the 17 respondents, one did not attempt a solution, another said it was not possible, and the other four all drew adequate grids but appeared to have miscounted the number of horizontal or vertical units necessary for the correct area. The four incorrect answers were triangles of (i) base 4, height 2, (ii) base 2, height 2, (iii) another of base 4, height 2, and (iv) base 1, height 3. This indicates that perhaps teachers were unsure of how to determine the area of a triangle from first principles or that they were unsure of the formula.

#### 5.11.2.3 The Errors of Upper Primary Teachers

The three most difficult questions from the Form A and Form B Upper Primary subtests were 34, 35 and 25, and 25, 31 and 34, respectively (see Table L.6). As well as questions 34 and 25 being free-response, they were common so their responses have been pooled.

Question 34, on parabola, was answered correctly by 46% of Upper Primary respondents. Twenty one percent made no attempt at the question, 8% gave the response 'sun orbit',

and another 8% gave the response 'waves'. One possible reason for teachers being incorrect is that parabolae and parabolic motion are often considered together with other examples of mathematics in nature, e.g. the planets and their elliptical orbits, and wave motion. Therefore, confusion often results.

Question 25 was answered 48% correctly. Of the other responses 13% proposed that a regular pentagon would tessellate and 23% made little or no attempt to answer.

Question 35 in Form A was also a difficult question (see Table 5.31) being dependent on knowledge of the definition of 'reflex'. It seems that there was some confusion regarding the terms 'complementary', 'supplementary' and 'reflex', choices 'b', 'c' and 'd', respectively.

The other difficult question in the Form B Upper Primary subtest was number 31 (see also Table 5.31). The commonest incorrect response, 'b', could have resulted from a lack of knowledge of longitude and its measurement west of 0 degrees.

#### 5.11.2.4 Summary of Teacher Errors

This description and brief comment on some of the errors of teachers was included so that examples of the types of errors or misconceptions most commonly possessed by teachers on the material they teach could be given. It was not possible, of course, to note any underlying patterns in errors because of the small number of questions examined and performance on these only by the relevant teacher subsample.

Table 5.31

Percentages for the Responses of Upper Primary Teachers to the Upper Primary Subtest Form A, Question 35, and Form B, Question 31

Choice	Question	
	Form A, No. 35 (N = 22)	Form B, No. 14 (N = 30)
a	5	13
b	18	30
c	27	10
d	46*	47*
e	5	(not possible)
No answer	5	0

\* indicates the correct response

### 5.11.3 The Errors of Student Teachers

Many of the most difficult questions for teachers were also the most difficult for student teachers. The analysis that follows parallels that for teachers except that for Primary student teachers the SATT Middle Primary and Upper Primary subtests have been combined into the SATT Primary subtest.

#### 5.11.3.1 The Errors of Infant Student Teachers

The three most difficult questions from the Infant subtest were 12, 4 and 7, and 12, 7 and 9, of Form A and Form B, respectively (see Table L.10). As questions 12 and 7 were common their responses have been pooled (see Table 5.32).

Question 12: as with Infant teachers, there seemed to be a confusion of 'pyramid' with 'prism' as together choices 'a' and 'd' accounted for 52% of responses. Question 7: as with Infant teachers, Infant student teachers were mistaken in a number of ways. It seems that some, at least, of the incorrect responses resulted from the failure to notice the mutually exclusive attributes 'thick' and 'thin'.

The free response question 4 in Form A was also a difficult question (only 12.5% correct) for Infant student teachers. Mostly the problem was in the correct naming of solid number 4, the hexagonal prism. Eighteen percent made no response. Some of the 61% of incorrect responses were hexagonal, hexagonal cylinder, hexagon, hectagon, octagon, hexoid, octagonal prism, pentagon, and hexahedron. Solid

Table 5.32

Percentages for the Responses of Infant Student Teachers to the Infant Subtest Questions 12 and 7 and Form B, Question 9

Choice	Question		
	No. 12 (N = 112)	No. 7 (N = 112)	Form B, No. 9 (N = 56)
a	17	35*	9
b	13	18	2
c	11*	30	30
d	35	13	7
e	23	3	48*
No answer	2	1	4

\* indicates the correct response

number 2, the pyramid, was incorrectly answered by 23% of Infant student teachers. Some of the incorrect names were tetrahedron, triangle, triangular prism, and quadrahedron.

The third most difficult question in Form B was question 9 (see also Table 5.32). The most popular incorrect response, choice 'c' of 9 units, may have resulted from a faulty mental image or a faulty sketch. Interestingly enough, this problem has obvious implications for the 'Number' strand of the Primary Mathematics Guidelines as well. The 'block' of the Multibase Arithmetic Blocks (MAB), a highly recommended concrete aid, is composed of 'unit' blocks and question 9, phrased differently, would occur often while working with the base 3 set. Whether this deficiency of Infant student teachers would also be manifested in the concrete situation is another question but in any case it indicates that half of Infant student teachers seemed incapable of dealing with or drawing composite cubes.

#### 5.11.3.2 The Errors of Primary Student Teachers

The three most difficult items from the Primary subtest were questions 35, 25 and 36, and 31, 19 and 36, from Forms A and B, respectively (see Table L.11).

The responses to Form A question 35 (Table 5.33) showed an apparent ignorance of the definition of 'reflex'; it was most commonly confused with 'supplementary'.

Question 25 was the next most difficult question in Form A for Primary student teachers. Twenty three percent gave a correct response. Of the others, 36% drew a regular pentagon

Table 5.33

Percentages for the Responses of Primary Student Teachers to the Primary Subtest Form A, Question 35; Form B, Question 31, and Question 36

Choice	Question		
	Form A, No. 35 (N = 39)	Form B, No. 31 (N = 42)	No. 36 (N = 81)
a	13	17	38
b	10	62	5
c	54	7	32*
d	8*	14*	17
e	10		0
No answer	5		2
a, c			4
a, b, c			1

\* indicates the correct response

and 28% did not attempt an answer or gave an incomplete answer.

The results of the third most difficult question in Form A and Form B was the common question 36 (see also Table 5.33). The popularity of choice 'a' indicates that many Primary student teachers did not understand 'isosceles'; while the triangle PIG is clearly right angled, the lengths of the sides are clearly all different.

The responses to the most difficult Form B Primary subtest question for Primary student teachers, question 31, are also given in Table 5.33. The popularity of choice 'b' indicated that Primary student teachers either did not understand the notion of longitude or constructed a faulty mental image from the geographical information given.

The next most difficult question in Form B was the free response number 19 (see Table 5.34). It seems that many Primary student teachers did not know what a regular pentagon looked like or were not able to reasonably accurately sketch one. It could be that many of them were familiar with only non-regular pentagons, accounting for the choice '1 pair'.

#### 5.11.3.3 Summary of Student Teacher Errors

As with the teacher errors this description and brief comment on some of the errors of student teachers was included so that examples of the types of errors or misconceptions most commonly existing with the material they will shortly be teaching could be given. Of course, it was not possible to note any underlying patterns in errors



Table 5.34

Percentages for the Responses of Primary Student Teachers to  
the Primary Subtest Form B, Question 19  
(N = 42)

Choice (number of pair)	Percentage
0	29*
1	29
2	10
3	12
4	5
5	7
other	2
no response	7

\* indicates the correct response

because of the small number of questions examined and performance on these only by the relevant student teacher subsample.

#### 5.12 Summary

In this chapter a description of the performance of teachers and student teachers on SATT and MST1 was given. The description of SATT performance was given not only in terms of total test score for each sample but also in terms of subtest score for each of the relevant subsamples, for teachers, Infant, Middle Primary and Upper Primary, and for student teachers, Infant and Primary. (The percentage correct on each item at the subsample level was given in Appendix L.)

As well, the first group of research hypotheses was tested. They were all retained: there were no significant differences in total test or subtest performance by Infant or Primary student teachers.

In Section 5.8 a summary of teacher and student teacher SATT comment was presented and the diversity of attitudinal comment was noted. In Sections 5.9 and 5.10 comparisons were made between the performance of trial survey teachers, postal (i.e. main) survey teachers and student teachers. It seems highly likely that the differences in performance between teachers and student teachers were attributable to test setting.

Finally, in Section 5.11 the errors of the teacher and student teacher subsamples on the most difficult items of their relevant subtest were tabulated and briefly discussed.

## CHAPTER 6

## THE TESTING OF RESEARCH HYPOTHESES - II

6.1 Introduction

In this section relationships between SATT score and the other variables in this study, e.g. MST1, secondary mathematics background, sex, age, and level of teaching, are explored. Much of the analysis which follows is not, in the strict sense of the word, theory-dependent, but is instead exploratory. This is not only because the literature in the area is sparse and itself often exploratory in its statistical analyses, but also because in this study some of the variables, most importantly 'level of teaching', are, with the partial exception of Pigge et al. (1979), novel.

The two main samples in the study, teachers and student teachers, are treated separately because of the different test settings, the postal survey for teachers and examination conditions for student teachers. The two statistical techniques used are univariate multiple linear regression and univariate analysis of covariance (ANCOVA). The first technique, regression, enables the measured variables (if significant), in this case MST1 score and age, to optimally predict or account for SATT score. The second technique, ANCOVA, is a test between subsample means on 'adjusted' SATT score, the subsample being formed according to various

criteria, e.g. sex, age or level of teaching. The 'stepdown' analysis model of ANCOVA was followed as it was felt that there may be a temporal, experimental or causal order among the factors when considered together (Overall and Spiegel, 1969). This model has the power to reduce the number of statistically significant factors where there is shared variance.

#### 6.2 Special Considerations Required by the Data and the Exploratory Analyses

As it was expected that there would be many separate analyses performed it was realised that statistical procedures which could deal with nonorthogonal (i.e. unequal cell size) factorial designs and give the correct, rather than inflated, error rates was necessary (Finn and Mattsson, 1978). Further, it was necessary to select a statistical package capable of stepdown ANCOVA. Given these two criteria the statistical package MULTIVARIANCE VI (Finn, 1980) was used.

In each ANCOVA model the number of degrees of freedom among the means was equal to the number of cell means, assuming that each cell had at least 1 subject. On both occasions there were empty cells and so a revised model was used with a smaller number of degrees of freedom. Any subject with at least 1 piece of missing relevant data was excluded from each analysis.

### 6.3 Teacher SATT Score

#### 6.3.1 Teacher SATT Score and Regression

SATT score was used as the dependent variable and the two measured variables, MSTl score and age, were used as the two predictor variables in that order in the multiple linear regression model to test the two hypotheses, THo6 and THo7 (Section 3.3.1). Table 6.1 is a summary of the regression analysis.

There are two noteworthy features of this table. First, the percentage of variance explained by the predictor 'age' over and above that explained by MSTl score was non-significant. That is, THo7 is retained. Second, the percentage of variance explained in SATT score by MSTl score, 27.01%, was significant at the .001 level. That is, THo6 is rejected.

#### 6.3.2 Teacher SATT Score and ANCOVA

In this section SATT score is also the criterion measure. Since the teacher regression indicated that MSTl score alone significantly explained SATT variance, only MSTl was used as a covariate here. That is to say, in this section the interest is in the relationship between SATT score and various factors (to be listed shortly) with that SATT variance attributable to MSTl score removed. While the study could have concerned itself with SATT score without a covariate, i.e. without possible reduction in variance due to MSTl score, such was included since it is arguable that some

Table 6.1

Summary of the Linear Regression Analysis for Teachers

Source of variation	Percent of variation explained
MST1	27.01***
Age, eliminating MST1	.22

\*\*\*  $p < .001$

SATT questions might have a spatial abilities component. The spatial abilities score was therefore used as a 'control', and the residual variance was examined. This residual variance can perhaps be thought of as the syllabus-specific knowledge component of the SATT score.

There were nine factors of potential significance in accounting for the remaining variance in SATT score: sex, secondary mathematics background, type of teacher training, level of teaching, initial qualifications and their upgrading, years of teaching, classroom responsibility, size of school, and whether feedback of test results was requested. Each of these factors was tried in turn as part of a one way ANCOVA.

Some explanation of the subsamples in each of the one way ANCOVAs is now given. Sex: teachers were divided into two subsamples on the basis of sex, females (N=139) and males (N=32). Secondary mathematics background: two subsamples were formed, one for those who had completed up to but not beyond Grade 10, and the other for those who had completed Grade 11 or Grade 12. The number in each subsample was 111 and 60, respectively. Type of teacher training: two subsamples were formed according to whether teachers had an 'integrated' type of teacher training (N=126), or a one year end-on Diploma of Education (N=45). Level of teaching: there were three subsamples, Infant (N=81), Middle Primary (N=34) and Upper Primary (N=49). Upgrade: the diversity in teacher training background and subsequent upgrading pattern was reduced to

two subsamples. The first subsample was composed of those who had completed a four year teacher training course either initially or through upgrading. As well, teachers who had completed some upgrading studies, even if they had not reached four year status, were also included. The second subsample was formed from the rest; those who had not completed at least one upgrading study or who did not already have four year status. The subsample numbers were 127 and 44, respectively.

The sixth factor was years of teaching. The levels of this factor were formed thus: teachers who had four or less years of teaching became subsample 1 (N=56); teachers who had five to nine years of teaching became subsample 2 (N=41); 10 to 14 years, subsample 3 (N=26); 15 to 19 years, subsample 4 (N=19); and greater than 19 years, subsample 5 (N=27). Classroom responsibility: two subsamples were formed from those who had full-time responsibility for a class (N=137) and those who did not, e.g. principals, vice-principals, librarians, senior teachers, infant mistresses, etc. (N=32). Size of school: the seven Tasmanian Department of Education criteria for school size were used as factor levels. The size of school and number in each subsample was, from largest to smallest; Class 1A (N=64), Class 1 (N=42), Class 2 (N=26), Class 3 (N=21), Class 4 (N=14), Class 5 (N=7), and Class 6 (N=4). Feedback on results: two subsamples were formed, those who requested to know their testing results (N=134) and those who did not (N=44).



The results of these nine one way ANCOVAs are given in Table 6.2. There were four factors significant, sex, secondary mathematics background, and feedback (all at the .05 level), and level of teaching (at .001). Therefore, THo10, THo12, THo13, THo14 and THo15 were retained and THo8, THo9, THo11 and THo16 were provisionally rejected.

These four significant factors were next combined in a four-way factorial stepdown ANCOVA. Their consideration suggested that the factors 'secondary mathematics background' and 'level of teaching' should be considered as 'control' or 'blocking' variables (Finn and Mattsson, 1978). That is to say, 'secondary mathematics background' will be entered first into the analysis as it was the more antecedent, and 'level of teaching' will be entered second. Given these 'control' variables it was then decided to enter 'feedback' as the third factor, i.e. the first of the experimental factors and 'sex' as the fourth factor, i.e. the second experimental factor. This order of factors implies the question: Is there a significant 'sex' effect after variance attributable to the first three factors has been removed? In other words, are all four factors necessary to account for significant variance in SATT score, or are only three, or even two, necessary?

The order of effects and initial estimation of degrees of freedom are given in Table 6.3 in the middle column. Specifically, the hypotheses investigated (in the null form) were, that there are no significant differences between means

Table 6.2

Summary of the One Way Analyses of Covariance for the Nine Factors for Teachers

Factor	N	% of variance accounted for by the covariate, MST1 score	df	F ratio
Sex	178	25.24	1, 175	6.5004*
Sec. Maths Background	171	27.69	1, 168	4.2323*
Training	175	27.11	1, 172	0.2813
Level of Teaching	168	27.96	2, 164	59.8910***
Upgrading	175	28.11	1, 172	0.0074
Years of Teaching	173	26.71	4, 167	0.9748
Responsibility	174	29.16	1, 171	0.0368
School size	178	28.51	6, 170	0.7200
Feedback	178	25.78	1, 175	5.3190*

\*  $p < .05$

\*\*\*  $p < .001$

Table 6.3

Analysis of Variance for the Teacher Four Way Crossed Design

Source of Variation	Degrees of Freedom	
	Full Model	Revised Model
Constant (M)	1	1
Secondary Maths Background (A)	1	1
Level of Teaching (B)	2	2
Feedback (C)	1	1
Sex (D)	1	1
AB	2	2
AC	1	1
AD	1	1
BC	2	2
BD	2	2
CD	1	1
ABC	2	2
ABD	2	1
ACD	1	1
BCD	2	1
ABCD	2	1
Among means	24	21
Within groups	N - 24	N - 21
Total	N	N

on adjusted SATT score formed by subsamples according to the two experimental factors, 'sex' and 'feedback', THo8' and THo16', respectively. As three of the 24 subsamples formed by the intersection of the levels of the factors had no members the number of degrees of freedom of the model was revised. The revision is given in the right hand column of Table 6.3.

A summary of the ANCOVA for the four factors and their interactions is given in Table 6.4. There are three noteworthy features of these results. The first is the nonsignificance of the pooled interaction terms. The second is the nonsignificance of the second (in order of entry) experimental factor 'sex'. The apparently significant sex effect in Table 6.2 was mainly attributable to an overlap with 'level of teaching'.

The third noteworthy feature of the analysis is the significant 'feedback' effect. Its  $F$  ratio was hardly unchanged indicating that its variance was virtually orthogonal to that of the first two factors. The subsample which asked for feedback scored, on average, higher than the subsample which did not.

In terms of the null hypotheses THo8' was retained and THo16' was rejected. The null hypotheses dealing with the factors 'secondary mathematics background' and 'level of teaching' (THo9 and THo11) were, of course, not tested again and their rejection stands as before.

Table 6.4

Summary of Analysis of Covariance for the Teacher Factors  
Secondary Mathematics Background, Level of Teaching, Feedback,  
and Sex on SATT Score

Source of Variation	df	Mean Squares	F ratio
Constant (M)	1	-	-
Sec. Maths Background (A), eliminating M	1	53.54	4.7359*
Level of Teaching (B), eliminating M and A	2	103.91	9.1917***
Feedback (C), eliminating M, A and B	1	56.82	5.0262*
Sex (D), eliminating M, A, B and C	1	.59	.0523
Interactions, eliminating all else	15	6.84	.6051
Within groups (Covariate	142 1)	11.30	
Total	164		

\*  $p < .05$

\*\*\*  $p < .001$

(Amount of variation accounted for by the covariate, MST1,  
is 25.66%)

#### 6.4 Student Teacher SATT Score

##### 6.4.1 Student Teacher SATT Score and Regression

This section is similar to that for teacher regression on SATT score. Recall SHol7 and SHol8 (Section 3.3.2). These covariates were used so that any significant variance due to MSTl score, and age could be removed thus leaving an 'adjusted' SATT score with a higher variance due to 'syllabus-specific' knowledge.

Table 6.5 is a summary of the regression analysis. It can be seen that, first, age was nonsignificant after variance attributable to MSTl was removed and second, MSTl was significant (at the .001 level). This means that SHol8 was retained and SHol7 was rejected.

##### 6.4.2 Student Teacher SATT Score and ANCOVA

The model used in this section was similar to that used in the section on teacher SATT scores and ANCOVA. The dependent variable remained SATT score and there was one covariate, MSTl score. This meant that adjusted SATT score had a higher variance attributable to 'syllabus-specific' knowledge as variance due to MSTl score was removed.

Initially each of the four hypotheses, SHol9 to SHo22, were tested in a one way ANCOVA. Each were found to be significant (see Table 6.6). As with teachers, consideration of these four factors led 'secondary mathematics background' and 'course of study' to be considered as 'control' or 'blocking' factors. That is to say, the null hypotheses SHol9 and SHo20 were rejected. The factors 'feedback' and 'sex'

Table 6.5

Summary of the Linear Regression Analysis for Student Teachers

Source of variation	Percent of variation explained
MST1	50.66***
Age, eliminating MST1	.24 (ns)

\*\*\*  $p < .001$

Table 6.6

Summary of the One Way Analyses of Covariance for the Four Factors for Student Teachers

Factor	N	% of variance accounted for by the covariate, MST1 score	df	F ratio
Sec. maths background	186	43.71	1,183	29.2908***
Course of study	193	51.83	5,186	6.5027*
Feedback	193	47.85	1,190	6.4388*
Sex	193	50.67	1,190	4.9132*

\*  $\underline{p} < .05$

\*\*\*  $\underline{p} < .001$



were considered as the first and second experimental factors, respectively. In other words, the 'sex' factor was the last factor to be entered into the analysis and the first to be tested for significance. Null hypotheses SHo21 and SHo22 became SHo21' and SHo22', respectively.

Here, as in the previous section on teacher SATT score and ANCOVA there were modifications to the degrees of freedom in the full model of the four-way factorial design. The initial estimate of the degrees of freedom, i.e. the full model, is reported in the middle column of Table 6.7. As 13 of the 48 subgroups formed by the intersection of the levels of the factors contained no members the degrees of freedom were revised (see the right hand column of Table 6.7).

A summary of the ANCOVA for the four factors and their interactions is given in Table 6.8. The interactions were nonsignificant. Also, neither 'sex' nor 'feedback' were significant. Therefore, SHo21' and SHo22' were retained. Comparison of Tables 6.6 and 6.8 shows that the decline in the magnitude of both the 'sex' and 'feedback' effects was mainly attributable to an overlap with the factor 'secondary mathematics background'.

Table 6.7

Analysis of Variance for the Student Teacher Four Way Crossed Design

Source of Variation	Degrees of Freedom	
	Full Model	Revised Model
Constant (M)	1	1
Secondary Mathematics Background (A)	1	1
Course of Study (B)	5	5
Feedback (C)	1	1
Sex (D)	1	1
AB	5	4
AC	1	1
AD	1	1
BC	5	5
BD	5	5
CD	1	1
ABC	5	2
ABD	5	2
ACD	1	1
BCD	5	4
ABCD	5	-
Among means	48	35
Within means	N - 48	N - 35
Total	N	N

Table 6.8

Summary of Analysis of Covariance for the Student Teacher Four Way Crossed Design

Source of Variation	df	Mean Squares	F ratio
Constant (M)	1	-	-
Secondary Mathematics Background (A), eliminating M	1	332.50	32.2908***
Course of Study (B), eliminating M and A	5	28.09	2.7284*
Feedback (C), eliminating M, A and B	1	33.87	3.2898 <sup>+</sup>
Sex (D) eliminating M, A, B and C	1	3.14	0.3049
Interactions eliminating all else	26	8.96	0.8706
Within groups (Covariate	150 1)	10.30	
Total	186		

<sup>+</sup>  $p < .08$

\*  $p < .05$

\*\*\*  $p < .001$

(Amount of variation accounted for by the covariate, MST1, is 39.69%)

### 6.5 Summary

In this section several regression analyses and ANCOVAs for teachers and student teachers were reported. Regression analysis for teachers showed MST1 score to be significant and age to be non-significant. ANCOVA analyses for teachers were in two stages. The first stage consisted of nine one way ANCOVAs using MST1 score as the covariate to determine which factors were significant. The second stage consisted of using the significant factors of stage one, sex, feedback, level of teaching, and secondary mathematics background, in a four-way stepdown ANCOVA. The interactions and 'sex' effect were both nonsignificant but the 'feedback' effect was significant.

Regression analysis for student teachers showed age to be nonsignificant and MST1 score to be significant. This significant covariate was used in a four-way stepdown ANCOVA using the factors sex, feedback, course of study, and secondary mathematics background. The interactions and the main effects 'sex' and 'feedback' were all nonsignificant.

The nonsignificant sex effect on adjusted SATT score for both teachers and student teachers is a different result from that of a number of other studies, e.g. Keith (1970), though often these studies did not look at 'sex' dis-confounded with other scores.

Regarding the significant feedback result for teachers, one possible interpretation is that those who were not competent with Spatial Awareness material, unlike student teachers, also did not wish to know about it.

Further comment on the findings will be found in Chapter

7.

## Chapter 7

## INTERPRETATION AND DISCUSSION

7.1 Teacher and Student Teacher SpatialAwareness Competence7.1.1 Introduction

The design of this project was influenced by two main shortcomings apparent in previous studies in the area. These were noted in Chapters 1 and 2. First, little account would seem to have been taken of the distribution of the levels of responsibility in the teacher or student teacher samples. Second, little concern was given to the relevance of the mathematics or geometry tests or items in the test to those levels of responsibility. Dettrick (1981) is an example. Even though the sample of teachers covered a Kindergarten through Grade 6 range, the analysis indicated little if any distinction between teachers having different grade levels of responsibility. As well, most of the test items used appear weighted towards the Upper Primary level.

The discussion in this section takes account of such shortcomings and, inter alia, will deal with the performances of teachers and student teachers on their relevant subtests. Comment on the research hypotheses will be found in Section 7.2.

### 7.1.2 SATT Competence

Notwithstanding the above, total SATT performances will be discussed first. The only large-scale studies of teacher geometry competence to compare with the present study were Backman (1969) and Keith (1970). However, in the former study teachers did their geometry test under examination conditions so any inferences regarding relative competence would be confounded. Keith's (1970) postal survey potentially provides the more relevant comparison for the performance of teachers in the present study. Unfortunately, her data were based on a response rate of slightly less than 30%, as opposed to the response rate of the present project of slightly less than 80%. Such a large difference in the response rate precludes any comparison due to possible sampling bias.

Comparisons between the geometry competence of the present student teacher sample and other student teacher samples, Bailey (1969), Banning (1971) and Ferguson (1972), would be confounded by the considerations mentioned previously in Chapters 1 and 2, the distribution of the intended teaching level of the sample and the distribution of questions, relevant to classroom practice, over these teaching levels. Therefore, no comparison of geometry competence is given.

### 7.1.3 SATT Subtest Competence

The data on teacher SATT subtest performances are given in Section 5.3.3. Even though Middle Primary teachers had the highest mean score on their subtest this result should be

interpreted in the context of the results of the comparisons in Tables 5.3, 5.4 and 5.5 on subtest performance. On the three subtests Upper Primary teachers had the highest mean scores, as they did on SATT [ $F(2,165)=11.83$ ,  $p<.001$ ]. These subsample results for Upper Primary teachers were similar to the results of Backman (1969) and Pigge, et al. (1979) who found that teachers in the upper Elementary grades had the highest mean, although these results may have been due to bias in the distribution of questions towards the upper Elementary grades. In the present study it seems that the Middle Primary subtest may have been the easiest thus giving the Middle Primary teachers the highest subtest score on their relevant subtest. Why Upper Primary teachers should have the highest subtest and test means is not clear. It could be that teachers strong in mathematics self-select towards the Upper Primary because of what they perceive to be the more challenging mathematics possibilities there. The reverse may hold too, that those teachers weak in mathematics tend to self-select for the Infant grades as they perceive the mathematical demands there to be less, as the results of Infant teachers on their subtest confirms the results of these two studies and that of Weaver (1966) that Infant teachers perform the least well of all.

It was not possible to compare the performance of student teachers on their relevant subtest with that of any other study. In the present study it will be recalled that there was no significant difference between Infant and Primary



student teachers on the Infant subtest but that there was a significant difference (at the .01 level) in favour of Primary students on the Primary subtest (Tables 5.10 and 5.13, respectively).

#### 7.1.4 Competence on Individual Items

##### 7.1.4.1 Teacher Competence on Individual Items

In many respects, teacher performances on items from their respective subtests (Tables L.4, L.5 and L.6) constitute the kernel of this research. From an inservice remediation viewpoint, these item-by-item performances yield the most potentially useful information on teacher Spatial Awareness competence. Adopting a 75% mastery criterion (similar to Dettrick's (1981) level of 80%) as reasonable, Infant, Middle Primary and Upper Primary teachers achieved satisfactory mastery on 13, 12 and 12 items out of 20 (allowing for common items), respectively. The items on which unsatisfactory mastery was achieved are those which suggest special assistance from inservice mathematics educators.

A comparison of the performance of teachers with that from other surveys on identical SATT questions was possible only with Dettrick (1981). These data will be found in Section 7.5.

##### 7.1.4.2 Student Teacher Competence on Individual Items

Amongst the most useful information on student teacher competence in this project is that contained in Tables L.10 and L.11 where data on Infant and Primary student teacher competence on the individual items of the relevant subtest

are given. Again, if we take 75% as being the criterion for mastery then it can be seen that Infant and Primary student teachers achieved mastery on 11 out of 20 items and 15 out of 40 items (allowing for common items), respectively. The data from these tables, together with the error tabulation in Section 5.11.3, give information of a kind which can be used directly with student teachers. In some cases the remediation needed is self-evident as the content is not, of course, sophisticated.

It was not possible to compare the performance of student teachers on individual items with that from other surveys as none have appropriate data.

#### 7.1.5 Competence on the Themes

An interesting feature of the individual item data was the sometimes widely differing proportion of correct answers with a pair of different questions from the same Theme. It will be recalled from Section 4.2.5 that one of the reasons for having two parallel forms of SATT was that it might enable competence on a question to be separated from that on a Theme. It would seem that such a hope was too simplistic.

The fact that there were a number of pairs of questions from Themes with markedly dissimilar proportions of correct answers is noteworthy for two reasons. First, it meant that the content validation group, and the present author, inaccurately estimated some item difficulties. This, however, did not have any major repercussions for the study since, as noted previously, these errored questions were spread

reasonably evenly over form of SATT and level of teaching. Second, it meant that inferences regarding Thematic competence are perhaps more difficult to assess than initially envisaged.

## 7.2 Relationships with Spatial Awareness Competence

### 7.2.1 Introduction

Hypotheses of three types were tested; those dealing with teachers, those dealing with student teachers, and those dealing with both. In this section the results of hypotheses testing are discussed, together with some comparisons with data from other studies of teacher and student teacher mathematical and geometrical competence.

### 7.2.2 Teacher Hypotheses

The teacher hypotheses related to regression and ANCOVA. Regression: recall THo6 and THo7 (Table 6.1). That THo6 was rejected at the .001 level was not surprising given the results of the studies quoted in Chapter 2 (e.g. Smith, 1964; Battista, Wheatley & Talsma, 1982). This is further evidence for the view that there are positive and at least low-level correlations between spatial abilities and geometry competence. However, the correlation coefficient ( $\sqrt{.2701} = .5197$ ) is quite high in comparison with these studies. This could be due to a number of reasons. First, it could be that, as the two tests were done in the one sitting with MST1 coming first, subjects continued in a spatial mode and used more spatial strategies with SATT than they might have had the tests been given at different times or in the reverse

order. Second, it could be that notwithstanding the different rationales and validation procedures for the tests that there may nonetheless have been items from SATT which were of a strong spatial abilities character. Consider Theme numbers 26 and 27, 'Problem solving using geometric shapes' and 'Construction and investigation of solids', respectively, which were the bases of questions 26 and 27 of SATT. It is conceivable that these four questions also tapped spatial abilities. The rejection of THo7 agrees with a similar finding by Keith (1970).

ANCOVA: recall THo8 to THo16 (Table 6.2). Five hypotheses were retained, THo10, THo12, THo13, THo14 and THo15 dealing with training background, upgrading, years of teaching, nature of professional responsibility, and school size, respectively. Teacher training (THo10): it seems that the apparent potential of an 'integrated' programme for more and better Spatial Awareness learning by student teachers makes no significant difference to SATT score in the long run. However, further comment on this is made in Chapter 8. Upgrading: THo12 was retained and, as can be seen from Table 6.2, had the lowest F ratio of any of the 9 one-way ANCOVAs. It is possible that a useful distinction could be made in any similar study in the future between different types of courses chosen for upgrading. Recent prospecti on teacher upgrading courses in Tasmania show that there were few courses available dealing with mathematics or geometry. Consequently, the upgrading of initial qualifications made no

significant difference to Spatial Awareness competence. Years of teaching (THol2): this non-significant difference accords with the finding of Keith (1970) but not with that of Backman (1969). The latter found a significant correlation of  $-.34$  between geometry test score and years of teaching experience, a result which may be attributable to the large number of 'New Math' questions on the geometry test. Less experienced teachers may have been trained on the 'New Math' and hence their geometry test score may have been higher. Professional responsibility (THol4): the non-significant difference was unexpected. It seemed reasonable that those who did not have a full-time classroom responsibility might allow their Spatial Awareness competence to decline. However, this non-significant result would suggest that such is not the case. School size (THol5): this factor was included in the study partly because Dettrick (1981) reported an "unexpected trend" which suggested that teachers in large schools (i.e. with  $> 200$  pupils) performed less well than those teachers in smaller schools (i.e. with  $< 200$  pupils). Although he did not report if the trend was tested for significance the factor 'school size' was thought to be of sufficient interest to include in the present study. The non-significant result of the present study agrees with that of Keith (1970).

Next, the four significant factors (at the .05 level) of this first stage were used in a stepdown ANCOVA (using MST1 score as the covariate) in the order 'secondary mathematics background', 'level of teaching', 'feedback', and 'sex', the

first two factors being 'control' or 'blocking' factors and the second two factors the 'experimental' factors. This meant that the analysis tested THo8' and THo16', respectively, and that THo9 and THo11 remained rejected.

Firstly, THo9 and THo11; that secondary mathematics background (THo9) was significant as a dichotomized factor (on average, those who had completed at least one year of mathematics in grades 11 and 12 performed better than those who had not), seems reasonable if one bears in mind the optional nature of mathematics in Grades 11 and 12. It seems reasonable to assume that secondary students who opt for mathematics in the last years of Secondary school are, on average, more interested in mathematics, have a more positive attitude towards mathematics, and are more proficient in mathematics than their non-mathematics elective colleagues. Dettrick (1981) found that secondary mathematics background accounted for an increment of 3% in explained variance on BMCT score in a step-wise regression analysis, after 'Enjoyment of maths' and 'sex' had together accounted for 18% of variance, although the percentage of explained variance attributable to 'secondary mathematics background' if entered first in the regression analysis was not reported. In spite of the fact that in the present study 'secondary mathematics background' is used differently compared with Dettrick's study (a factor versus a measure) the finding corroborates Dettrick's finding of its importance. In a study of the numeracy competence of two groups of Victorian first-year

Primary student teachers Foster (1978) found that there was a significant difference at the .001 level favouring those who had completed Grade 11 mathematics when secondary mathematics background was dichotomized into subsamples using a similar criterion to that used in the present study, those who had taken mathematics up to but not beyond Grade 10, and those who had completed Grade 11.

These results possibly contradict the findings of Keith (1970) who found that there was no significant correlation between the number of years of high school or college mathematics and geometry test score. Comparisons with this finding are however difficult because it was not known how much geometry was included in U.S. high school and college mathematics courses. Tasmanian Secondary schools (and more recently Matriculation colleges) have traditionally included some geometry.

The factor 'level of teaching' (THoll) was also rejected (at the .001 level). In order of competence (highest to lowest) the subsamples were Upper Primary, Middle Primary and Infant. Unfortunately, some studies (e.g. Pigge, et al., 1979) have not tested this factor for significance but rather have reported a trend that was of interest. Other studies have reported contradictory findings. Backman (1969) found a correlation of .55 between geometry test score and grade level taught. However, Keith (1970) found that 'grade level' (apparently on a two-level factor, possibly lower and upper Elementary) was non-significant. Dettrick (1981) reported

that 'grade level' (also apparently on an Infant and Primary dichotomy) accounted for 3% of the variance in BMCT score. The data from Pigge, et al. (1979) showed a marked tendency of teachers to score higher the higher their grade level of responsibility, although the level of significance associated with these differences was not reported. The present results showed significant differences between the means, with the means in the same order as that for Pigge, et al. (1979).

One of the implications of the present finding of significant differences between the three subsamples is that this factor could be a criterion upon which to base inservice workshops or remediation. The present policy of dichotomy of Infant and Primary teachers in inservice work may not go far enough by failing to include the Middle Primary level of interest. Taken together the rejection of both THo9 and THo11 means that of the six subsamples (two levels of 'secondary mathematics background' x three levels of 'level of teaching') formed by these two factors the two subsamples most 'at risk' would appear to be Infant and Middle Primary teachers who did not proceed further than Grade 10 in mathematics.

Secondly, the two experimental factors (in order of interpretation) 'sex' (THo8) and 'feedback' (THo16) will now be considered (Table 6.4). (It was found that all the interactions were non-significant. This was of little concern since the purpose of the study was an examination of main effects.) The non-significant sex effect, after variance



attributable to 'secondary mathematics background', 'level of teaching' and 'feedback' was removed, perhaps supports the conclusions of one previous study but not another. Recall that in the present study on a one-way ANCOVA 'sex' was a significant factor at the .05 level (THo8). Keith (1970) found 'sex' to be non-significant on a one-way ANOVA. However, Dettrick (1981) found 'sex' to account for an additional 4% of variance (from 14% to 18%) when it was entered second in a step-wise regression analysis after 'Enjoyment of Mathematics'. The extent of variance attributable to 'sex' had it been entered first in this regression analysis was not stated. Nor is the significance of the factor 'sex' in a one-way ANOVA known. In any case, in the present study there was a rather dramatic change in the significance of 'sex' when it was the last of the main effects to be entered in the ANCOVA. It can be seen that the significant sex effect of Table 6.2 was, in fact, because of overlap with 'level of teaching'. One obvious consequence of the retention of THo8 is that it would be pointless for inservice mathematics educators to form groups of teachers for remediation, instruction or activities by sex.

The second experimental factor 'feedback' was of special interest as it was the only attitudinal aspect of the study. This rejection of THo16 is noteworthy for two reasons. First, it gives further evidence for the view that there is a link between attitude and achievement in mathematics and geometry, as those who wished to know of their results scored

(significantly) higher than those who did not. Although the magnitude of the connection and its nature is at times keenly debated, practically all of the evidence suggests important links between them (Aiken, 1970 and 1976). Second, it can be interpreted that those teachers who are not interested in their mathematics competence are usually those who need remediation most.

Amongst the subsamples formed by the three significant factors of 'secondary mathematics background', 'level of teaching', and 'feedback' those most 'at risk' would appear to be Infant and Middle Primary teachers with only a Grade 10 or less background who did not wish to know of their SATT test result.

### 7.2.3 Student Teacher Hypotheses

The student teacher hypotheses related to SATT score, SATT subtest score, regression and ANCOVA.

SATT score: recall SHo1 and SHo2. Both of these hypotheses were retained. Although interpretation of these retentions could be confounded by differences between the subsamples in, for example, mathematics or geometry competence which existed prior to the commencement of teacher training, and secondary mathematics background, there is no evidence to suggest that such was the case. Therefore, these non-significant differences were perhaps surprising as it will be recalled that the teacher training background of the groups was quite different. Whereas both B.Ed. groups were in their 4th year of teacher training the Dip.Ed. group was,

strictly speaking, merely in its first year. Both B.Ed. groups had had three years of mathematics education as one of a number of compulsory studies, and while the majority of this time was spent on Number, a little time was also spent on Spatial Awareness. Furthermore, as a practicum is a part of each year's B.Ed. course it is conceivable that there was also classroom exposure to Spatial Awareness in the preceding three years, exposure which was not a part of the degree structure of Dip.Ed. students. That both these hypotheses were retained is additionally surprising as it seems that neither Dip.Ed. course contained provision for specific Spatial Awareness instruction. It seems that three years of student teacher training, the difference in the length of time between the B.Ed. and Dip.Ed. programmes, made no significant difference in Spatial Awareness competence.

Regression: recall SHol7 and SHol8 (Table 6.5). SHol7 was rejected at the .001 level of significance and MST1 accounted for a large 51% of variance in SATT score. This is possibly a larger percentage of accounted variance (and correlation) than any reported in the literature. This could be partly attributable to the same reasons offered for the variance in teacher SATT score accounted for by MST1 score, i.e. that MST1 and SATT were done in that order in the one sitting, and that SATT items may have tapped spatial abilities. Additionally, however, it could be that the extra percentage of variance is attributable to the fact that little 'syllabus-specific' Spatial Awareness work was done in

the B.Ed. courses. If this were so, student teacher SATT scores might have been lower than if more 'syllabus-specific' Spatial Awareness work had been covered. More SATT questions would have to be answered from first principles, perhaps involving strategies drawing upon spatial abilities. This possibly would have the effect of making SATT appear to be more of a spatial abilities test than would otherwise be the case.

SHo18 (age) was retained. This result is similar to that obtained by Bailey (1969) and Ferguson (1972) who found that number of years since last mathematics course was also non-significant. One consequence of this non-significant result is that it would appear that mature age student teachers would perform non-significantly differently on SATT in comparison with younger student teachers (spatial abilities being equal).

ANCOVA: recall SHo19 to SHo22 (Table 6.6). All four factors appeared significant and they were entered in a four-way stepdown ANCOVA in the order 'secondary mathematics background', 'course of study', 'feedback', and 'sex'. This order of factors was used to test for a sex effect, and if non-significant to test for a feedback effect. That is to say, the first two factors were entered as 'control' or 'blocking' factors and the last two factors were the experimental factors, now SHo21 and SHo22 (Table 6.7). Therefore, SHo19 (secondary mathematics background) and SHo20 (course of study) were both rejected (Table 6.8). In the case

of SHol9 there was a significant difference on 'adjusted' SATT score in favour of those who had at least one year of Grades 11 and 12 mathematics. This result, similar to that found for teachers, is probably attributable to the same reasons, that those who opt for mathematics in the last years of Secondary school when it is no longer compulsory, on average, have more of a positive attitude towards mathematics and are more proficient in mathematics. However, this rejection of SHol9 is a different result from that of both Bailey (1969) and Ferguson (1972) who found that the completion of a college mathematics course was not a significant predictor of geometry test score. Interpretative comment is difficult because it is not known how much geometry was included in U.S. College mathematics courses. It could be that there was little geometry as Ferguson (1972) also tested whether the completion of a college geometry course was a significant predictor of geometry test score and found that it was.

In the case of SHo20 (course of study) its rejection was not surprising as a similar factor with teachers, 'level of teaching' (THol1), was also significant. (This hypothesis involved an ANCOVA with six levels and should not be confused with hypotheses SHol and SHo2 which each contained an ANCOVA with three levels (Tables 5.11 and 5.14). SHo20 can be thought of as a combination of SHol and SHo2.) The order of 'adjusted' SATT score means for the six subsamples were (highest to lowest): TCAE B.Ed. Primary group, U of T B.Ed.

Primary group, U of T Dip.Ed. Primary group, U of T B.Ed. Infant group, TCAE B.Ed. Infant group, and U of T Dip.Ed. Infant group. As can be seen from this ordering by subsample mean, the Primary subsamples performed better than the Infant subsamples, as too did the two B.Ed. groups versus the Dip.Ed. group within the teacher training dichotomy. The teaching level result is similar to that obtained by Pigge, et al. (1979) on mathematics test result. It could be that Infant student teachers self-select partly because of a relative inability with or less positive attitude towards mathematics and that Primary student teachers also self-select partly for the opposite reasons.

The two experimental factors, 'sex' and 'feedback', were both non-significant and so both hypotheses, SHo22' and SHo21', respectively, were retained. That 'sex' was not a significant factor for student teachers agrees with the result for teachers in the present study (THo8') and possibly with the finding of Bailey (1969) that sex was not a significant predictor of geometry test score. One implication of this result is that it would be non-sensical to organise courses or remediation on the basis of sex. The apparently significant 'sex' result of Table 6.6 was, in fact, mostly attributable to an overlap in variance with 'secondary mathematics background' and 'course of study'. That is to say, when accounting for 'adjusted' SATT score performance the variable 'sex' did not account for any additionally significant variance over and above that which was accounted

for by 'secondary mathematics background' and 'course of study'.

The retention of the 'feedback' hypothesis for student teachers is different from that for teachers (THo16'). This result means that when accounting for 'adjusted' SATT score variance the variable 'feedback' did not account for any further significant variance after that accounted for by 'secondary mathematics background' and 'course of study' was removed. Obviously, the connection that there is with teachers between feedback of SATT score and SATT competence is not as strong as with student teachers. Perhaps student teachers were not as convinced as teachers of the claim that SATT was based on the Spatial Awareness strand of the Primary Mathematics Guidelines and hence relevant to the classroom. They may also have thought that the Spatial Awareness strand was not important enough mathematically to bother with knowing of one's competence.

#### 7.2.4 Teacher and Student Teacher Hypotheses

These hypotheses (T&SHo3, T&SHo4, and T&SHo5) related to SATT score and SATT subtest score. Even though these hypotheses were all rejected a proper interpretation of these results needs to take account of the results of Sections 5.9 and 5.10. In Section 5.10.2 it was shown that there was no significant difference in SATT competence of teachers and student teachers under similar test conditions. Furthermore, in Section 5.9 it was shown that there was a significant difference (at the .001 level) between the SATT competence of

trial survey teachers and main (i.e. postal) survey teachers. As there was no reason for thinking that the Spatial Awareness competence of the trial survey teachers was extraordinarily deficient the obvious conclusion is that the significant difference between teachers on SATT performance was wholly attributable to test setting. Returning to the aforementioned hypotheses, one is led to a similar conclusion: that the significant differences in SATT and SATT subtest performance were wholly attributable to test setting. Recall that for student teachers the test setting was relaxed examination conditions. The standardised instructions (Appendix I) stated that there was no time limit on SATT but that subjects were to work reasonably quickly. Therefore, there would have been <sup>few</sup> opportunities for revision, going back to a skipped question and involved or complicated diagrams. Furthermore, student teachers were tested with no prior warning as to content.

On the other hand, teachers were alerted to the imminence of the arrival of the test by both the short article in the June, 1982 issue of The Tasmanian Teacher and, more importantly, the pre-letter. In that time teachers may have unconsciously or even consciously started to sensitise themselves to the contents of the Spatial Awareness strand, especially their level or grade of concern. Of course, this is not forgetting that presumably classroom teachers would have had a continuing commitment to at least a miniscule Spatial Awareness component in their mathematics programme so



it is conceivable that a small part of the Spatial Awareness strand may have been a topic of current concern. Also, the instruction advising that there was no time limit on SATT may have been taken literally. Some teachers may have spent an inordinate amount of time on individual questions or the test as a whole, even assuming that SATT was done in the one sitting, a questionable assumption given the professional and domestic demands on teachers. It seems likely that SATT would have often been done in more than one sitting.

It is difficult to know the extent to which teachers disregarded the instructions in the accompanying letter (Appendix J) not to consult colleagues, the Primary Mathematics Guidelines or other reference material. Certainly a number of teachers commented that they did observe examination conditions (Appendix K). In any case, if the request to observe examination conditions and not to consult was disregarded in part by the sample the bias in the response pattern was not sufficient to disguise the similarity between teacher and student teacher responses regarding many of the important questions of the study, e.g. the most difficult questions at each of the teaching levels.

### 7.3 A Recent Suggestion Concerning Teacher Training and Secondary Mathematics Background

In recent years in Australia there has been a renewed interest in numeracy and mathematical standards generally in the nation's schools. Part of this concern has been directed at teacher training and the secondary mathematics background of prospective teachers for it has long been felt that teachers play an important part in the formation of the abilities and attitudes of students of mathematics. This concern about the mathematical competence of especially Infant and Primary teachers has come from a number of sources. A.W. Jones (1979), then recently-retired South Australian Director-General of Education, said, "No student should be selected for entry to primary teacher education courses who has not completed successfully full English and Mathematics courses at secondary school level." The Australian Association of Mathematics Teachers in 1981 published a discussion paper Recommendations for Mathematics Teacher Education for Australian Schools in which they recommended, "... all students entering primary teacher education courses should have demonstrated success in mathematics at year 10 level and preferably have continued the study of mathematics in years 11 and 12."

As well, several Parliamentary committees in Australia have addressed this problem. The Report of the Select Committee on Education in Queensland (the Ahern Report, 1980) recommended, "... successful completion of ... Mathematics

and English in Years 11 and 12 ... shall be pre-requisites for registration as a teacher under the Queensland Education Act." The Senate Standing Committee on Education and the Arts in its Preparation for the Workforce (1981) echoed a similar recommendation, "That all teacher training institutions adopt minimum entry standards requiring completion of appropriate courses in mathematics and in English to Year 12 level."

The assumption underlying these quotations seems to be that successful completion of high school mathematics leads to more competent teachers of mathematics or leads to teachers with a more positive attitude towards mathematics. Questions of teaching competence and teacher attitudes in mathematics are outside the scope of this project but it is possible to test the idea that Tasmanian teachers and student teachers who have studied mathematics in the last years of high school are more competent with the material of the Spatial Awareness strand than those who have not. It will be recalled that such an analysis has, in fact, already been done with secondary mathematics background and 'adjusted' SATT score (Tables 6.2 and 6.6). These assumptions appear to be of such importance that it was decided to test for the effect of 'secondary mathematics background' on SATT unadjusted for the effect of the covariate, MST1 score.

Two subsamples from each of teachers and student teachers were formed, those who had studied only compulsory mathematics (up to but not beyond Grade 10) and those who had studied mathematics beyond Grade 10. As the numbers in the

subsamples were grossly uneven the non-parametric Mann-Whitney U test was used to test the significance of the difference in the scores. See Tables 7.1 and 7.2. The evidence from these tables would appear to support the assumption underlying the quotations that those who take mathematics courses in Grades 11 and 12 are significantly more competent than those who do not.

As previously mentioned in Section 7.2.2, these results also support the findings of Foster (1978) who found a significant difference (at the .001 level) on the numeracy attainment of two intakes of beginning first year Primary student teachers between those who had only studied compulsory mathematics (i.e. to Grade 10) and those who had studied mathematics at the Grade 11 level.

Table 7.1

Teacher SATT Scores and Secondary Mathematics Background

	Secondary Mathematics Background		z-score
	≤ Grade 10	> Grade 10	
N	111	60	-3.02**
Mean Rank	77.62	101.50	

\*\*  $p < .01$

Table 7.2

Student Teacher SATT Scores and Secondary Mathematics Background

	Secondary Mathematics Background		z-score
	≤ Grade 10	> Grade 10	
N	135	51	-6.60***
Mean rank	77.52	135.79	

\*\*\*  $\underline{p} < .001$

#### 7.4 New Topics in the Spatial Awareness Strand

##### and the Competence of Older Teachers

Many of the Topics and Activities of the Spatial Awareness strand of the (1978) Primary Mathematics Guidelines were new, relative to the 1966 syllabus. In Table 7.3 there is a list of these 17 new Themes together with their SATT question number. The main practical question suggested by this change in syllabus and the data of this study is this: Is the competence of teachers who were trained before 1978, i.e. before the introduction of the Guidelines, significantly different from the competence of newly trained teachers on these Themes?

The teacher sample was dichotomized on the basis of years of teaching: those who had four or less years of teaching formed one subsample while those who had more than four years teaching experience formed the other. The 'New Themes of SATT Score' was out of 17. Again, the Mann-Whitney U test was used. The difference between the scores of the samples was non-significant (Table 7.4). That is to say, it made no significant difference to teacher competence with the new material whether they were trained since the advent of the Guidelines or not.

Table 7.3

## Novel Spatial Awareness Themes

Theme	Question Number
Topology	3
Matching related 2D and 3D shapes	9
Pattern making	10
Tessellations	11
Angles - dynamic conception	16
Circles, discs and cylinders	20
Simple translation	22
Reflections	23
Geoboards	24
Tessellations	25
2D problem solving	26
Direction	28
Further angles	29
Maps	30
Latitude and longitude	31
Shadow projection	32
Parabola	34



Table 7.4

Teacher "New Themes SATT Subscore" and Years of Teaching Experience

	Years of Teaching Experience		z-score
	4 years	4 years	
N	56	116	-0.5273 (n.s.)
Mean rank	89.83	85.61	

### 7.5 A Comparison between Victorian and Tasmanian

#### Infant and Primary Teachers

It will be recalled from Table 4.4 and Appendix G that some of the borrowed SATT items were used unchanged. Comparisons with the competence of other samples of teachers was possible only with Dettrick (1981). Table 7.5 lists these five common questions and the corrected (using Yates' correction) chi-square value associated with the 2 x 2 contingency table [the two states (Victoria and Tasmania) by two types of response (right and wrong)] for each of them. Only one of the five questions was significantly different (at the .05 level) by proportion of correct responses and this favoured Tasmanian teachers. That there was only one such question was perhaps surprising given that the Tasmanian teachers were part of a postal survey and Victorian teachers were tested mostly in lieu of staff meetings, presumably under relaxed examination conditions. The results of Section 5.9 could suggest that because of possible differences in test setting Tasmanian teachers may have performed significantly better on more than one of the five questions. Of the other four non-significant questions the first three had almost identically similar proportions correct. On the basis of these five questions it would seem that there was no significant difference in the Spatial Awareness/Space Relations competence of the two groups of teachers.

Table 7.5

Comparison of Victorian Teachers (Dettrick, 1981) and Tasmanian Teachers on Identical Spatial Questions

Question	% Correct		Corrected $\chi^2$
	Victorian Teachers	Tasmanian Teachers	
Dettrick, I 30, SATT A q.14	56% (N = 130)	55% (N = 85)	.0000
Dettrick, III 16, SATT A q.27	55% (N = 128)	57% (N = 85)	.0134
Dettrick, II 9, SATT A q.28	79% (N = 130)	78% (N = 85)	.0114
Dettrick, I 28, II 7, III 20, SATT B q.16	56% <sup>+</sup> (N = 388)	63% (N = 93)	1.4379
Dettrick, I 4, SATT B q.27	48% (N = 130)	63% (N = 93)	4.8019*

<sup>+</sup> This question was an item common to all 3 tests. The 56% is the average of the individual percentages on each of the 3 tests.

\*  $p < .05$

### 7.6 Summary

In this chapter the results of the present study given in Chapters 5 and 6 were interpreted and discussed. In Section 7.1 teacher and student teacher Spatial Awareness Competence at the test, subtest, and item levels was discussed. For teachers at the test and subtest levels, Upper Primary teachers had the highest means, a result similar to that obtained by other studies which found that upper Elementary teachers had the highest mean score. At the item level within the relevant subtest it was found that 13, 12 and 12 items out of 20 (allowing for common items) were answered satisfactorily (assuming 75% mastery level as the criterion), respectively. A knowledge of these competences could obviously form the basis for inservice remediation. For student teachers the Primary subsample outperformed the Infant subsample. Infant student teachers achieved mastery (at the 75% level) on 11 out of 20 items and Primary student teachers on 15 out of 40 items. Similarly these competences could form the basis for pre-service teaching and remediation. There were no comparable student teacher studies.

In Section 7.2 on relationships with Spatial Awareness data the results of the various hypotheses from Chapter 3 were discussed. SATT score was the criterion variable. There were two teacher regression hypotheses, MST1 score and age. The first was rejected and accounted for approximately 27% of SATT score variance. This high value was attributed to the fact that the tests would have often been done in the one

sitting with MST1 first, and that some SATT items possibly called on spatial abilities. Age accounted for a non-significant proportion of variance after variance attributable to MST1 score was removed. Of the seven original teacher ANCOVA hypotheses five were retained and two ('secondary mathematics background' and 'level of teaching') were rejected. No comparisons are possible as these factors seem not to have been studied before. Two modified teacher hypotheses were also tested in a stepdown ANCOVA: 'sex' was retained and 'feedback' was rejected. The 'sex' result is similar to that found in one study but not another. The significant sex effect in the one-way ANCOVA became non-significant in the stepdown ANCOVA, as the variance previously attributable to the sex effect overlapped with variance attributable to 'secondary mathematics background'. The significant feedback factor in the stepdown ANCOVA was probably due to the fact that those teachers who were less competent on SATT, on average, were also those who did not wish to know about it. Of the student teacher hypotheses the first two related to performance between the Infant and Primary subsamples, respectively. These hypotheses were retained in spite of the fact that both Dip.Ed. groups were, in effect, only in their first year of teacher training and possibly having only their first exposure to Spatial Awareness for many years. The student teacher regression hypotheses dealt with MST1 score and age. The age hypothesis was retained but the MST1 score hypothesis was rejected; it

accounted for a large 51% of variance. This is possibly the largest percentage reported in the literature. It was thought that in addition to the reasons given for teachers to account for their amount of explained variance, there was also the possibility that student teachers had not had much 'syllabus-specific' Spatial Awareness instruction. This could have meant that they used more reasoning strategies based on first principles, including spatial strategies, than teachers and hence the two tests became more a measure of the same thing.

Two of the original four student teacher ANCOVA hypotheses ('secondary mathematics background' and 'course of study') were rejected probably for the same reasons as the corresponding teacher hypotheses were rejected and the two modified hypotheses ('feedback' and 'sex') were tested in a four-way stepdown ANCOVA and retained. The change in significance of the sex effect was, as in the case of teachers, attributable to an overlap in variance with the factor secondary mathematics background. The non-significant feedback factor in the four-way stepdown ANCOVA was different from the result obtained for teachers. Its variance was also partly due to an overlap in variance with 'secondary mathematics background'. This non-significance could have been either because student teachers were not as convinced as teachers that SATT was based on the Primary Mathematics Guidelines and hence relevant to classroom practice or that the Spatial Awareness strand was not important enough to bother with knowing of one's competence.

In Section 7.2.4 there was only brief discussion of the comparative results of main survey teachers and student teachers on SATT and the relevant subtest results because of test setting confound.

In Section 7.3 some recent Parliamentary and other suggestions concerning the efficacy of a full secondary mathematics background on Australian teachers' mathematics achievement and attitude were partly tested with some of the data of this survey and supported. It was found that there was a significant difference for both teachers and student teachers on SATT score in favour of those who had at least one year of optional mathematics in the last years of High School.

In Section 7.4 it was found that there was no significant difference on competence with material new to the 1978 Guidelines between teachers trained prior to its introduction and those trained since.

Finally, in Section 7.5 a comparison between Tasmanian and Victorian teachers on five common items showed only one significant difference, and this in favour of Tasmanian teachers. Because of the possible effect of test setting confound it was concluded that there were probably no significant differences in the Spatial Awareness/Spatial Relations competence of the two groups of teachers.

## Chapter 8

## CONCLUSION

8.1 Implications8.1.1 Entry into Teacher Training

The data of the survey, especially that on the relationship between SATT score and secondary mathematics background, contain implications for entry into teacher training as the factor 'secondary mathematics' background was significant for both teachers (Tables 6.4 and 7.1) and student teachers (Tables 6.8 and 7.2). And while this connection was not tested at the SATT subtest level for the relevant teacher or student teacher subsample it would be surprising if this connection were not at least partly maintained.

As already noted in Section 7.3 the secondary mathematics background of teachers and student teachers at the Infant and Primary levels has been a subject of Parliamentary and other concern. The results of the present study confirm part of the assumption of these Parliamentary inquiries that those who elect to study mathematics after it is no longer compulsory in high school have a significantly higher geometry competence than those who do not. Perhaps scholarships for entrants to Infant and Primary teacher training should be reserved for those who have a full secondary mathematics background.



### 8.1.2 Student Teacher Spatial Awareness Courses and Remediation

At the test level it will be recalled that SHo20 ('course of study') was rejected, and that the order of the means (highest to lowest) was TCAE B.Ed. Primary course, U of T B.Ed. Primary course, U of T Dip.Ed. Primary course, U of T B.Ed. Infant course, TCAE B.Ed. Infant course, and U of T Dip.Ed. Infant course. The two unmistakable trends were that Primary student teachers were more competent than their Infant colleagues and that the Dip.Ed. student teachers were less competent than their B.Ed. colleagues. While these trends were evident at the test level it is not clear how this information could lend itself to a teaching or remediation programme at the relevant teaching level. Rather, it seems that student teacher programmes in Spatial Awareness should be based on a knowledge of item competence from the relevant subtest possibly with emphasis on those items for which 75% mastery was not achieved. As well, of course, it should be remembered that the factor 'secondary mathematics background' was also significant (SHo19). In the unlikely event that two parallel classes in Infant or Primary Spatial Awareness within each course and year of training were possible it would seem that a natural division could be made on the basis of secondary mathematics background.

The rejection of the factors 'sex' and 'feedback' suggests that neither would be suitable criteria upon which to base pre-service Spatial Awareness programmes.

### 8.1.3 Teacher Spatial Awareness Courses and Remediation

The significance of the factor 'level of teaching' as the second factor in the four-way stepdown ANCOVA (Table 6.4) suggests that teachers from the three levels of teaching should be separated for inservice Spatial Awareness work. Although the Infant and Primary dichotomy is commonly preserved in inservice mathematics activities, there is usually no further subdivision of Primary teachers into Middle and Upper Primary groups.

It is not clear how the significance of the factor 'secondary mathematics background' can be used as a criterion to help in teacher inservice work. As with student teachers, it could be that in the unlikely event of a large number of teachers being available for inservice work that a distinction could be made in terms of secondary mathematics background.

The results of the two modified hypotheses on 'sex' and 'feedback' also have implications at the inservice level. There would be no point in forming groups of teachers for Spatial Awareness remediation or other Spatial Awareness inservice work on the basis of sex, but there would be for 'feedback'. However, the practical use of this criterion 'feedback' is another matter. Perhaps some of the policies of the Tasmanian Government's White Paper on Tasmanian Schools and Colleges in the 1980s (1981) in which teachers are expected to attend more inservice activities (Policy Statement No. 64), and there is to be a five-yearly report on teacher progress (Policy Statement No. 72) provide a structure to enable the feedback criterion to be most effectively used. Presumably the five-yearly reports would list attendance at

in-service seminars or other knowledge- and skill-enhancing activities (Policy Statement No. 62). It could simply be a matter of organising an in-service Spatial Awareness course for those who have not previously volunteered for Spatial Awareness (or perhaps, more generally, mathematics) courses. Of these, perhaps those with a Grade 10 or less background in Mathematics are especially 'at risk'.

In any case, the results of SATT subtests for teachers in Section 5.3.3 and the error tabulation in Section 5.11.2 give specific information on teacher strengths and weaknesses in Spatial Awareness which could undoubtedly be used directly for courses or for remediation in in-service situations or for consideration in any future syllabus changes in Spatial Awareness.

## 8.2 Some Other Questions

### 8.2.1 Introduction

In large-scale empirical studies there are often other questions besides those asked which in the opinion of some could have been also of theoretical or practical importance. The present study is possibly no exception. The author has been mindful of the potential practical importance of parts of the project and this has undoubtedly influenced both what has been reported and the way in which it has been reported. But if the project had had a different orientation some of the analyses reported would have been different. What follows in Section 8.2 is a brief discussion of some possibly useful questions to which the data of the present study could have addressed *themselves*, together with some suggestions for further studies.

### 8.2.2 Patterns in Errors

It should not be thought that because this project has concerned itself with individual item competence and has been at least mindful of Thematic competence that it was not aware of the possibility of patterns in SATT errors across groupings of questions on related topics. For example, there may be a pattern in the responses to questions 10, 13, 22 and 25 of Form A dealing with tessellations. However, such an analysis was not attempted since it would have required questions to be grouped across (and not within) teaching levels. While this might indeed produce useful information, the major concern of the present project was to study competence at these particular teaching levels.

### 8.2.3 SATT and MST1

There are a number of possibilities for investigation of the relationships between performance on SATT items and MST1 items. The first technique, that of canonical correlation, maximally relates the items of one test score to the items of another by testing for significant correlations between groups of items from both sets of data (Darlington, et al., 1975). In other words, the technique would enable the predictability of the entire criterion set (SATT items) to be determined from the entire predictor set (MST1 items). The data from such an analysis could help the understanding of any specific relationship(s) between spatial abilities and geometry competences.

The second technique involves the DIPT (the Dimensionality, degree of Internalization, the mode of Presentation, and the Thought Process) classification of spatial tasks of Wattanawaha

(1977) and used to classify the items of MST1. Such a classification could be used with SATT items to see if there were any important strengths and weaknesses with groups of items having the same or similar DIPT classifications. As well, it might be of interest to explore connections between responses to SATT items and MST1 items which were identically or similarly classified. Furthermore, the DIPT classification of SATT items could give additional insight into any specific relationship(s) between spatial abilities and geometry competences.

#### 8.2.4 SATT and Secondary Mathematics Background

Section 7.3 gave an indication of the importance of the relationship between SATT score and secondary mathematics background for both samples. It would also be of interest to note the relationship between the factor 'secondary mathematics background' and, firstly, the different levels of teaching and teacher training and, secondly, performance on individual SATT items from the relevant subtests. This information could perhaps also be used in remediation in teacher training courses and inservice work.

#### 8.2.5 MST1

In this project MST1 has mainly been used as a covariate to enable SATT score to be adjusted for a spatial abilities component. However, spatial abilities, although in the eyes of many teachers not of such immediate and obvious teaching relevance, nevertheless has long been a topic of educational and psychological concern. The data from this project could be used to investigate a number of potentially important questions. For example, what is the relationship between secondary mathematics background and MST1? Also, it would seem to be of interest to investigate the relationship between the factor 'secondary mathematics background' and MST1 item response, similar to the aforementioned proposal for SATT items. This could be extended to test all the factors of the study using MST1 as the criterion variable in a series of ANOVAs in a manner analagous to that reported in the present study for SATT score.

#### 8.2.6 Training Effect

It may also be of interest to explore any Spatial Awareness training effect in the student teacher sample by comparing their SATT and individual item performance with a sample of tertiary education students comparable on such criteria as secondary mathematics background and length of tertiary education but who have had no exposure to mathematical or spatial concepts in their tertiary education. Although in many ways the Dip.Ed. Infant and Primary student teachers may have had just such a non-mathematical background it may be useful to test tertiary students who were enrolled in courses either that were not

concerned with teaching or that did not lead to teaching. Such a comparison may reveal the Spatial Awareness topics or items that young adults know by virtue of their background and environment. This information could then provide additional information for the planning of pre-service Spatial Awareness courses.

#### 8.2.7 SATT Score and Attitude

This project has used only one variable with an attitudinal component, 'feedback'. It may be of interest in any future survey of teacher and student teacher geometrical or mathematical competence to include a larger attitudinal component in the questionnaire. This has already been done by Dettrick (1981) who found that the predictor 'Enjoyment of Maths' accounted for 14% of variance in BMCT score when entered first in a step-wise multiple linear regression analysis. How this related to teachers at their different levels of teaching was not reported so it could be of interest to relate attitudinal factors not only to total test score but also to the relevant subtest score. It would also be of interest to find the relation between the attitude to mathematics and its teaching, and secondary mathematics background.

#### 8.2.8 SATT Score and Pupil Attitude and Competence

Schofield (1981) studied the relationship between Primary teacher mathematical competence and the attitude and competence of their pupils. She found inter alia that teachers who scored highly on a mathematics test, in general produced pupils who scored higher than average on a mathematics test but whose attitude was lower than average. It may be of interest to see if this trend for mathematics was also maintained for Spatial Awareness on a test such as the present one, which is based on topics which are a part of the mathematics syllabus.

#### 8.2.9 SATT Score and Concrete Aids

It is explicit in the Guidelines that Spatial Awareness should be taught with concrete aids and that pupils should engage in activities with concrete aids. It could be of interest in any future project to include data on the use of concrete aids for Spatial Awareness teaching so that the relationship between SATT or SATT subtest score and the use of Spatial Awareness concrete aids in teaching could be explored (Bishop, 1973). Also, it would be of interest to find the relation between the use of concrete aids and response to the feedback option.



### 8.3 Conclusions

#### 8.3.1 SATT and the Number and Measurement Strands

This project has been concerned with one of the three strands of the Tasmanian Primary Mathematics Guidelines, the Spatial Awareness strand. It would be of interest to replicate the present study with a sample of teachers across the Infant and Primary grades from the other Australian states on their geometry/space syllabus. For example, there may be common geometric strengths and weaknesses, common relationships between geometry and spatial abilities and a common relationship with secondary mathematics background. In addition, it seems that the approach of this project and the importance accorded both to test items from the complete K-6 grade range, and the division of the samples into their respective levels of teaching, could also be used to test the competence of teachers and student teachers in the other strands of Number or Measurement not only from Tasmania but also from elsewhere. It has been stated before that Spatial Awareness, at least in Tasmanian Infant and Primary schools, is often the last in the queue for mathematics time. A project involving a test in Number or Measurement where much more mathematics teaching time is usually spent would appear to be especially worthwhile. Of course, in any test having a purpose similar to that of the present study it would be necessary to ensure that the present approach of using items relevant to all the teaching levels of the intended sample be used.

### 8.3.2 The Present Project and Classroom Practice

It is obvious that this project has concerned itself with an important part of the educational process, viz. the competence of Infant and Primary teachers and student teachers with a part of the mathematics syllabus they actually teach or will soon be teaching. The results of the project can be viewed two ways. First, as the test items were based on material from the Guidelines, they could be used in the classroom as activities either via the agency of the teacher or directly by pupils. It is also conceivable that Grade 6 pupils especially would be able to work through the test items qua test items. In this context, it is of interest to note that several teachers wrote that they were going to use SATT in their class.

The second way that this project, and in particular the results on individual SATT items from the relevant SATT subtest, is of potential use is through its effect on teachers and student teachers via the agency of inservice activities for teachers and via altered courses of study for student teachers. This agency is indispensable, for the results of this project will not magically change teacher and student teacher misconceptions or their possible under-emphasis of Spatial Awareness in their mathematics teaching. The data will need to be used by inservice and pre-service mathematics educators in ways that can best affect the quality and quantity of Spatial Awareness knowledge.

#### 8.4 Summary

In this concluding chapter the implications of the present study and some questions and suggestions for future study were stated. The implications of the study were at a number of levels. At the level of entry into teacher training the data endorsed the view of the Parliamentary enquiries that Infant and Primary teachers should have a complete secondary mathematics background. At the pre-service and inservice levels the data highlighted obvious strengths and weaknesses and provided a basis for remediation and teaching in terms of secondary mathematics background, level of teaching and, for teachers, attitude.

In Section 8.2 there were some additional questions which could be asked of the present data. For example, what is the relationship between MST1 score and the factors of the present study?

There were also a number of suggestions for future research, for example, an investigation of the relationship between teacher SATT score and the attitude and achievement of their pupils. As well, there was also the suggestion that the design of this study be replicated with the Number, and Measurement strands of the Guidelines.

Finally, the role of pre-service and inservice mathematics educators in using the results of this survey to improve teacher and student teacher Spatial Awareness competence was noted.

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Appendix A

The Spatial Awareness Strand of the  
Primary Mathematics Guidelines

## SPATIAL AWARENESS

## AIMS

To develop an awareness of, and an interest in, pattern and shape in the physical world.

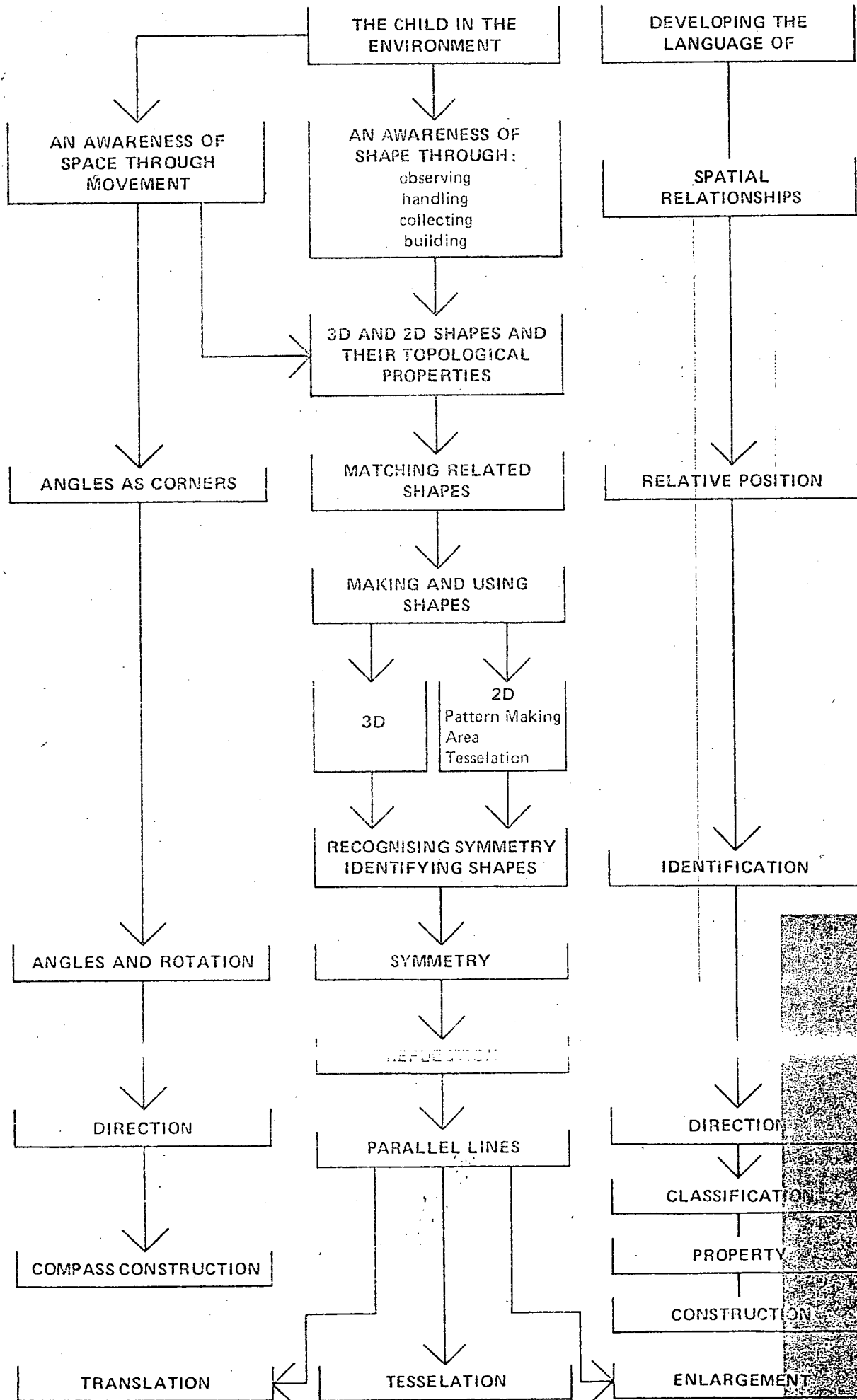
To develop an understanding of relationships between spatial entities in the immediate and in the extended environment.

To create an acceptance that the learning of mathematics includes the process of inquiry, discovery and verification, which arise from a curiosity about number, quantity and space.

To acquire an appropriate vocabulary for the effective communication of mathematical ideas.

To develop an understanding of inter-relationships among ideas of number, quantity and space.

# Spatial Awareness



## SPATIAL AWARENESS

## Suggested Sequence of Topics and Activities

## Teaching Notes and Comments

The child in the environment—movement.

Observing types of movement—animals, cars, trains, people.

Describing types of movement—fast, slow.

Positional language of body movement.

Direction—up, down, backwards, forwards, across.

Type—sliding, turning, rolling, swaying, jumping, pointing.

Awareness of shape.

Providing experience with three-dimensional objects including everyday things, classroom materials and building apparatus.

Develop language of topology.

Ideas of inside, outside, open, closed, straight, flat, curved.

Sorting three-dimensional shapes.

Objects used should include everyday things, classroom materials and building apparatus. Discussion should bring out the idea that the basis of sorting involves attributes, some of which are shape attributes.

Naming attributes.

Using objects sorted previously and attribute blocks.

Displaying types of shape in set form.

eg large, small, thick, thin, rectangles, balls etc.

Displays of shapes.

Classifying shapes.

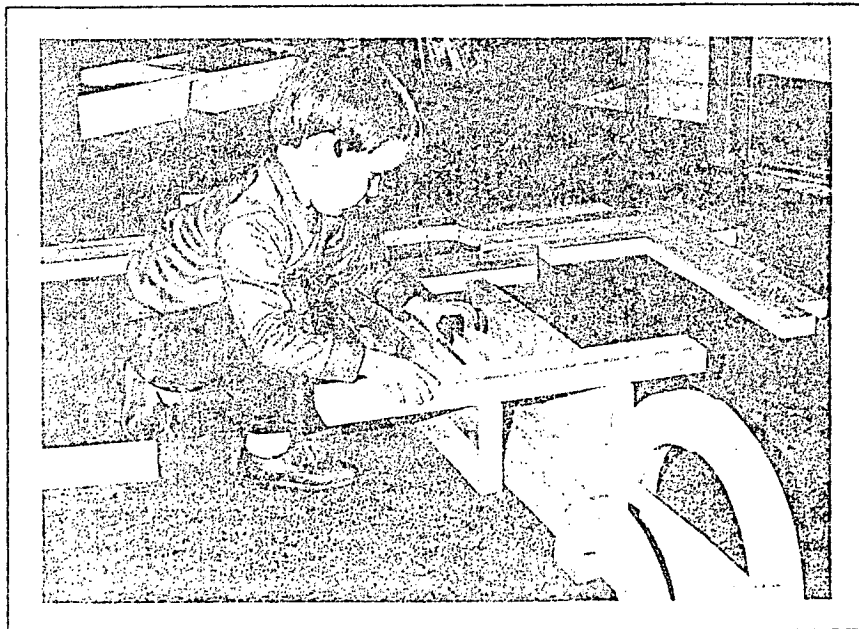
eg making a 'book of round things'.

Awareness and use of left and right.

Extension of description of body movement above.

Matching related shapes (natural and man-made).

In the environment—observation.  
Handling and cutting large squares, triangles, rectangles.



## SPATIAL AWARENESS

## Suggested Sequence of Topics and Activities

## Teaching Notes and Comments

Pattern making. Patterns with attribute blocks.

Pattern making with squares of two different colours.

Movement — rhythmic shapes.

Exploring and naming solids.

Finding plane shapes from solids.

Finding patterns in materials — wallpaper.

Children use body to make shapes.  
Describing the movement.

Solids in the environment.

Pentagon, hexagon, parallelogram, rhombus.

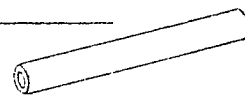
The children can cut out pictures of balls, buildings, toys, etc. to be used in making cards such as:

Write the names of two heavy cubes.  
Write the name of one light cube.

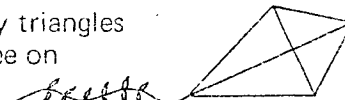
Find this shape.  
How many corners has it?



This water pipe is a \_\_\_\_\_.  
Is it solid or hollow?



How many triangles can you see on this kite?



How many cubes of the same size would you need to put together to make another cube?

What surface shapes can you see?

**Apparatus**

Collections of portable solids such as bricks, tubes, balls, tins, boxes, sweet cartons, straws, pipes, tiles, etc. Plastic and wooden mosaics, attribute materials, bricks, balls and cardboard cartons.

Comparing two like solids.  
Prisms, cubes, cones.

## SPATIAL AWARENESS

## Suggested Sequence of Topics and Activities

## Teaching Notes and Comments

Using plane shapes to cover surfaces.

List of things used to cover surfaces — carpet, lino, tiles, etc.  
Using prepared shapes to form patterns (tesselations).

Finding symmetry in the environment.

Bodies, faces, flowers, leaves, cars, wallpaper, floor coverings, materials, etc.

Constructing symmetries.

Paper folding and cutting.  
Blob painting.

Looking at corners — to develop the **static conception** of angle.

Investigating, exploring and talking about corners of shapes and solids in the classroom, the playground etc. The right-angle will be recognized.

Forming a right-angle by paper folding.

Comparing observed corners with the right-angle.

Use of tangram covering-puzzles can highlight right-angle relationships.

Some properties of common shapes.

Table of shape properties.

Plane shape	Number of Edges	No. of corners
eg square	4	4

Looking at turning to develop the **dynamic conception** of angle (Rotation), eg door keys, control knobs, windscreen wipers, wheels.  
Direction of turning.

Description of turns by fractions.

Left, right, clockwise, anti-clockwise.  
Road signs.

Introducing vertical and horizontal.

Observation of these in the environment.  
Using body movement.

Recognition of parallel lines.

Lines on papers, opposite edges of rectangles and squares, building, etc.

Drawing circles and forming discs.

Have children explore a variety of cylinders.  
Pattern making.  
Compass drawing.

Rotational symmetry — shapes which have rotational symmetry.

Investigation of stars, logos, crossword puzzle blanks, circle patterns, Maltese cross, etc.

Simple translations

Drawing polygons. Bring out ideas of reflection and line symmetry.  
Silhouettes.

Reflection made by folding and cutting.

Use of geoboard to investigate shapes, patterns, symmetry and reflection.



## SPATIAL AWARENESS

## Suggested Sequence of Topics and Activities

## Teaching Notes and Comments

Tesselations

Producing patterns and designs by translation, rotation and reflection of templates.

Problem solving using geometric shapes.

eg tangram, dissection puzzles.

Construction and investigation of solids — Platonic solids, cylinders, spheres.

Use of nets, skeleton models (Constructo straws, D stix, straws and pipe cleaners). Soma cube puzzles.

Direction and angles. Simple protractors and their use — sun dial, angles of elevation.

Aids to find direction.

Magnetic compass.  
Investigate uses — navigation instrument.

Using maps — direction giving by various means.

Giving instructions.  
Drawing plans. Simple orienteering.  
Free play with protractors.  
Grid references, eg battleships.

Latitude, Longitude.

Rotation of three-dimensional figures.

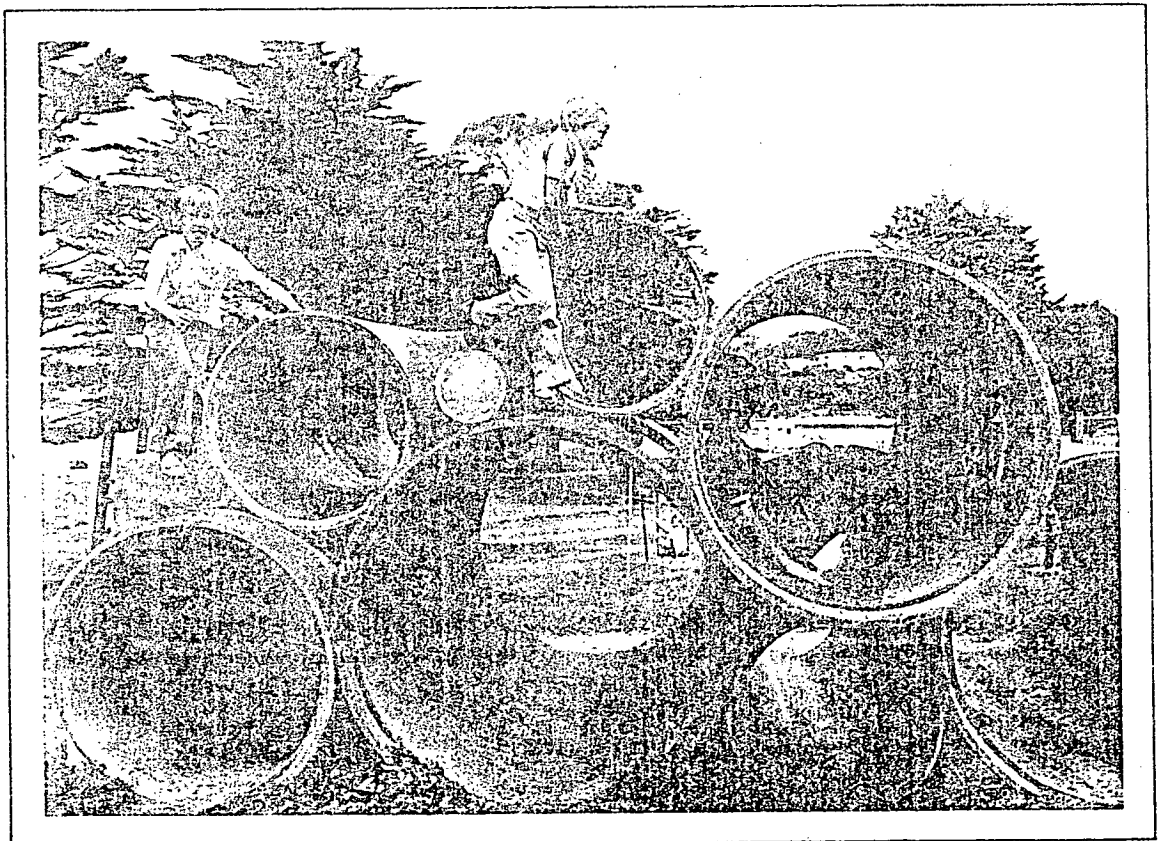
Shadow projection and identification.

Circles.

Vocabulary of circle.  
Investigation of ratio of circumference and diameter, the notion of  $\pi$ .

Golden rectangle — spirals.  
Wave curves, parabolas.

Existence of spiral patterns in nature, eg Fibonacci sequence in shells, flower heads, etc.



Appendix B

Additional Material on Spatial Awareness  
Published by the Tasmanian Education Department

Palmer, M.E. n.d. 1979a? Activities Using Geoboards.  
-----, " 1979b? Curves, Angles and Polygons.  
-----, " 1979c? Starting Points for Investigation  
and Discovery in Spatial Work.  
-----, " 1979d? Transformations and Tessellations.

## Appendix C

### Thematic Groupings of the Spatial Awareness Strand

INFANT SPATIAL AWARENESSTHEMATIC GROUPINGS

Activity No.	Topics and Activities	Theme No.
1	The child in the environment - movement.	1
2,4	Positional language and topology.	2
4	Topology.	3
3	Awareness of 3-D shape.	4
5,6,9,15	Sorting 3-D shapes, shape attributes and their names.	5
7,8	Displaying types of 3-D shapes in set form.	6
10	Left and right.	7
11	Matching related 2-D and 3-D shapes.	8
12,13	Pattern making.	9
14	Movement - rhythmic shapes	10
16	Finding plane shapes from solids	11
17	Comparing two like solids	12

MIDDLE PRIMARY SPATIAL AWARENESSTHEMATIC GROUPINGS

Activity No.	Topics and Activities	Ther
18	Plane shapes on plane shapes.	1
19,20	Symmetry.	1
21,22,23	Angles - static conception.	1
25,26	Angles - dynamic conception.	1
24	Properties of common 2-D and 3-D shapes.	1
27	Vertical and horizontal.	1
28	Parallel.	1
29	Circles, discs and cylinders.	2
30	Rotational symmetry.	2
31	Simple translations.	2
32	Reflections made by folding and cutting	2
33	Geo-boards - shapes, patterns, symmetry and reflections.	2

UPPER PRIMARY SPATIAL AWARENESSTHEMATIC GROUPINGS

Activity No.	Topics and Activities	Theme No
34	Tesselations.	25
35	Problem solving using geometric shapes.	26
36	Construction and investigation of solids.	27
37,38	Direction.	28
37	Further angles.	29
39	Maps.	30
40	Latitude and longitude.	31
41	Shadow projection geometry.	32
42	Further circles.	33
43	The golden section, golden rectangle and spirals	34
44	Wave curves and parabolas.	35

Supplementary material on Spatial Awareness since the publication of the  
Guidelines.

Publication	New Material	Theme
1. Palmer, M.E. n.d. 1979a. Activities Using Geoboards. Geoboards (Theme 24) Tesselations (Themes 13, 25) Symmetry (Theme 14) Transformations (Theme 24)		
2. Palmer, M.E. n.d. 1979b. Curves, Angles and Polygons Curves (Themes 3 and 34) Locus (Themes 33, 34, 35) Angles (Themes 15, 16) Polygons (Themes 17, 26)  Triangles   Quadrilaterals	Acute, obtuse reflex. $A_1$ Regular, irregular. Convex, non-convex.  Scalene, isosceles, equilateral. Acute-, right-, obtuse angled. Angle sum. Parallelogram, rhombus, rectangle, square, kite, trapezium. Scalene.	
3. Palmer, M.E. n.d. 1979c. Starting Points for Investigation and Discovery in Spatial Work. The 5-piece tangram (Theme 26) Pentominoes (Theme 26) Hexiamonds (Theme 26) Bicycles Containers (Theme 27) Grids		
4. Palmer, M.E. n.d. 1979d. Transformations and Tesselations. Translations (Theme 22) Reflections (Theme 23) Rotations (Themes 16, 21) Tesselations (Theme 13, 25) Regular Polygons and Tesselations (Themes 13, 25, $A_2$ ) Non-regular Polygons and Tesselations (Themes 13, 25, $A_2$ ) Creating Tesselations using Transformations (Themes 13, 25, $A_2$ )		
Primary Mathematics, No. 1, March, 1980. Tesselating with regular pentagons (Themes 13, 25, $A_2$ )		
Primary Mathematics, No. 2, July, 1980. Activities using the Hexagon grid (Theme $A_6$ )		
Primary Mathematics, No. 3, October, 1980. Designs using 4 regular hexagons (Theme $A_2$ ) With 4 L's (Themes 13, 26)		
Primary Mathematics, No. 4, March, 1981. Tangrams (Theme 26) Finding half the area (Theme 24)		
Primary Mathematics, No. 6, October, 1981. Dissecting hexagons (Themes 26, $A_2$ )		



Appendix D

SATT (Pilot Versions) and Questionnaire

SPATIAL AWARENESS TEACHING TEST

(Pilot Study)

NAME: \_\_\_\_\_

SCHOOL: \_\_\_\_\_

SEX (tick the correct one): Female/Male

AGE (tick the correct one): 20-24/25-29/30-34/35-39/40-44/45-49/50-54/55-59/60-64

AT WHAT INSTITUTION DID YOU DO YOUR INITIAL TEACHER TRAINING? \_\_\_\_\_

FOR HOW MANY YEARS WAS YOUR INITIAL TEACHER TRAINING? \_\_\_\_\_

FOR HOW MANY YEARS HAVE YOU BEEN TEACHING? \_\_\_\_\_

DO YOU HAVE FULL-TIME RESPONSIBILITY FOR A CLASS? \_\_\_\_\_

If YES, what grade do you currently teach? \_\_\_\_\_

(If you teach a composite class, just indicate the grade that has the most children.)

If NO indicate which of Librarian, Infant Mistress, Senior Teacher, Principal, etc. you are. \_\_\_\_\_

WHICH AREA OF TEACHING IN THE INFANT OR PRIMARY SCHOOL ARE YOU MOST INTERESTED IN?

(Tick one) Infant (Grades K - 2)

Middle Primary (Grades 3 and 4)

Upper Primary (Grades 5 and 6)

TO WHAT LEVEL DID YOU STUDY MATHEMATICS IN THE SECONDARY SCHOOL? (tick the correct one). year 7 / 8 / 9 / 10 / 11 / 12

The answers to these questions and the Spatial Awareness Teaching Test are strictly confidential. Upon completion please return to:

Mr Kevin Anderson,  
 M.Ed. student,  
 Department of Educational Studies,  
 Centre for Education,  
 University of Tasmania,  
 G.P.O. Box 252C,  
 HOBART, Tas. 7001.

## THE SPATIAL AWARENESS

TEACHING TEST. Form A.

NAME: \_\_\_\_\_

1

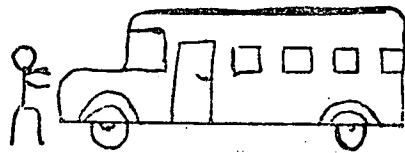
Which of the sets of adjectives listed below best corresponds in order to the movement verbs SPRINT, WALK,

- (a) fast, slow, medium
- (b) slow, medium, fast
- (c) medium, fast, slow
- (d) slow, fast, medium
- (e) medium, slow, fast.

Answer: A

---

2. Which word or phrase best describes the position of the bus driver in relation to the bus?

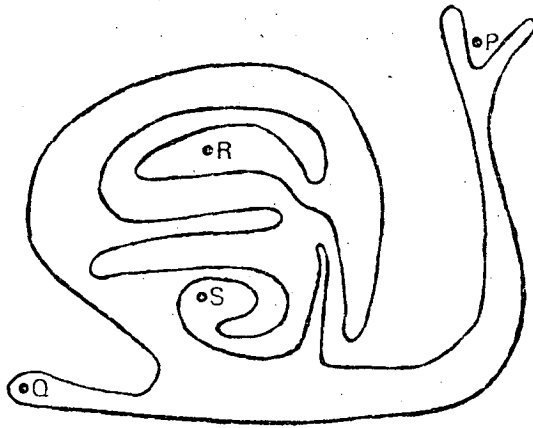


- (a) under
- (b) over
- (c) behind
- (d) away from
- (e) in front of

Answer: E

3/

For the simple closed curve illustrated, which point(s) are outside the curve?



A P only

C P and R

B P and Q

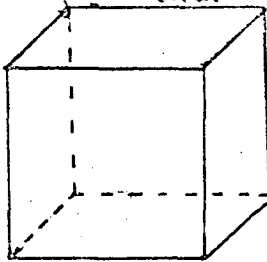
D P and S

Answer:

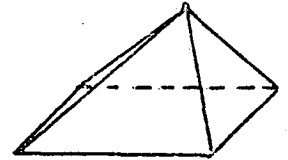
D

Questions 4, 5 and 6 relate to these four solids

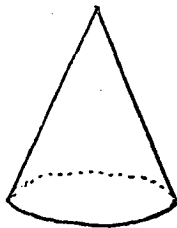
1/



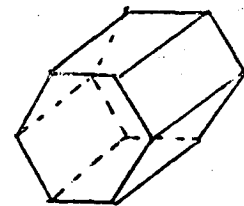
2/



3/



4/



4) Name the four solids

1/

CUBE

2/

PYRAMID

3/

CONE

4/

HEXAGONAL PRISM

- 5) Describe two sets into which the solids could be divided. Indicate by numbers which solids you would put into each set.  
Description: \_\_\_\_\_

See Appendix F.

Solid numbers: \_\_\_\_\_ + \_\_\_\_\_

- 6) Describe another 2 sets into which the solids could be divided. Indicate by numbers which solids you would put into each set.  
Description: \_\_\_\_\_

See Appendix F.

Solid numbers: \_\_\_\_\_ + \_\_\_\_\_

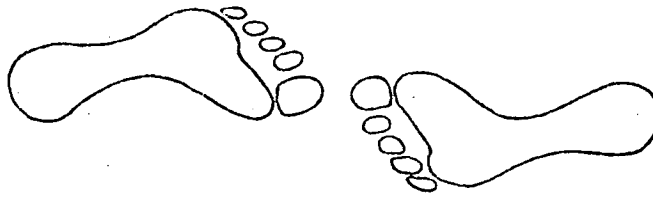
- 7) There are 2 sets of attribute blocks, set A and set B. Set A contains only medium sized thin objects. Set B contains only thick circles. Which of the following is the best description of the intersection or overlap of A and B?

- (a) empty set
- (b) medium sized circles
- (c) thick and thin medium objects
- (d) thick and thin circles
- (e) thick objects

Answer: A

8)

These two foot prints were seen on the sand.



They were made by

- A a left foot and a right foot.
- B two left feet.
- C two right feet.
- D none of the above are correct

Answer: B

- 9) A large square has the length of one of its edges twice as long as the edge of another square. How many smaller squares are needed to cover the larger?

(a) 2

(b) 3

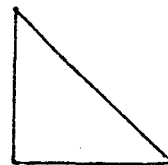
(c) 4

(d) 8

(e) Can't tell without a measurement for the two squares

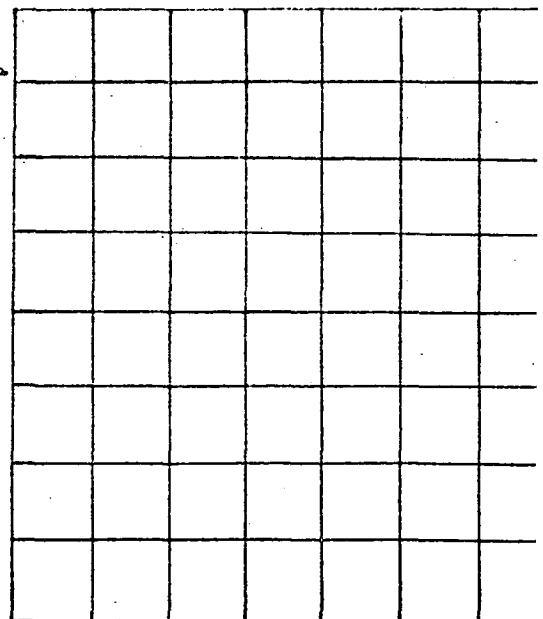
Answer: C

- 10) Using this triangle completely fill up the square.



make a pattern which will

See Appendix F.



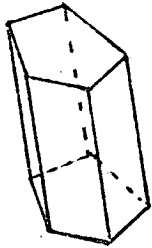
11) How many squares are there on the surface of a cube?

- (a) 1
- (b) 4
- (c) 6
- (d) 9
- (e) 16

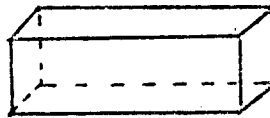
Answer: C

12)

(1)



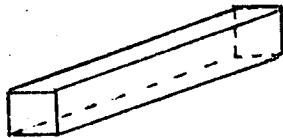
(2)



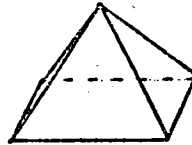
(3)



(4)



(5)



Of the figures above the following show prisms:

- (a) figure (5) only
- (b) figure (3) only
- (c) figures (1), (2), (3), and (4) only
- (d) figures (1), (2), (3), (4), and (5)
- (e) none of the above choices is correct.

Answer: C

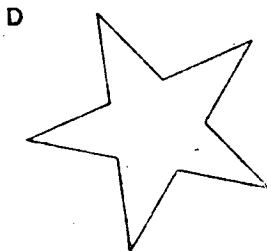
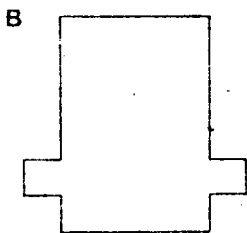
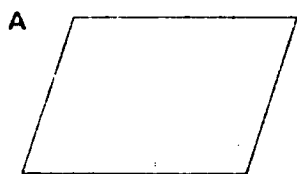


13. What is a tessellation? Give an example. \_\_\_\_\_

See Appendix F.

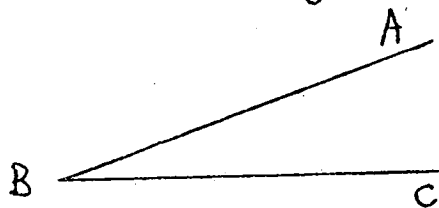
14.

Which one of the following shapes has no axes of symmetry?



Answer: A

15. Consider the following diagram:



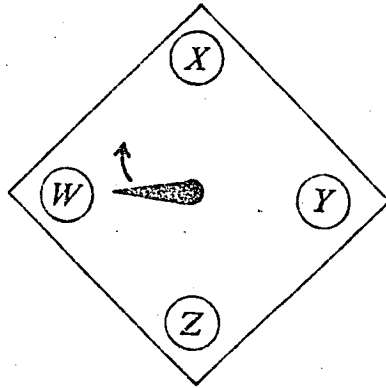
In what way do the lengths of AB and BC affect the measure of angle B?

Answer:

No affect.

16.

Look at the picture below.



The pointer turns **only** in the direction shown by the arrow. When the pointer is turned from *W* all the way round to *W* again it has made a complete turn.

The pointer is pointing towards *W*. If turned three quarters of a turn the pointer will be pointing towards

- A *X*.
- B *Y*.
- C *Z*.
- D *W*.

ANSWER: - C

17. Consider a rectangular block of wood.

How many surfaces or faces has it? 6

How many edges has it? 12

How many corners has it? 8

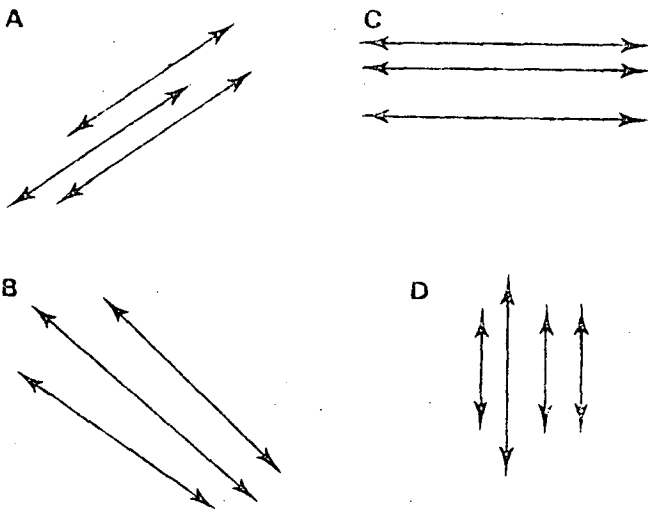
18. Which of the following is the best example of horizontal?

- (a) The side of a hill
- (b) The surface of a calm pond
- (c) The side of a tall building
- (d) A car wheel
- (e) A slippery dip.

Answer : B

19

Which one of the following is a group of lines which are **not** parallel?



Answer : B

20. A circle has a radius the same length as the side of a square. How many squares will fit inside the circle without overlapping?

- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) cannot tell without the length of the radius and/or the side of the square

Answer: A

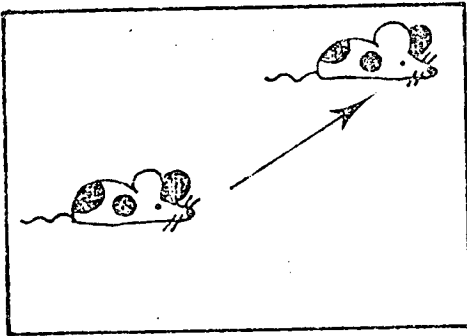
21. How many lines of rotational symmetry does a circle have?

- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) infinite

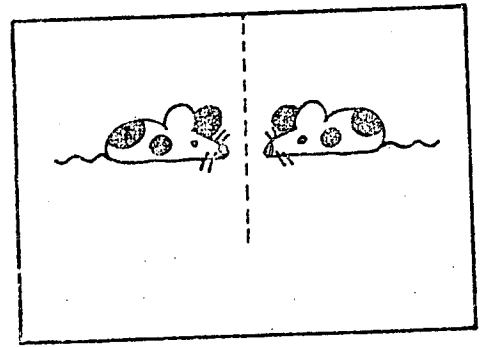
Answer: E

22. The diagrams show two types of movement

A



B



The type of movement in A

- is:
- (a) rotation
  - (b) reflection
  - (c) translation
  - (d) none of the above

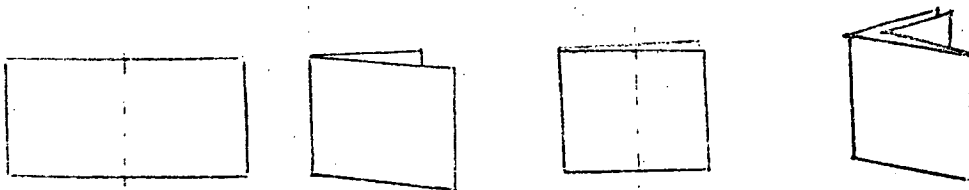
- and in B is:
- (a) rotation
  - (b) reflection
  - (c) translation
  - (d) none of the above

Answer: A C

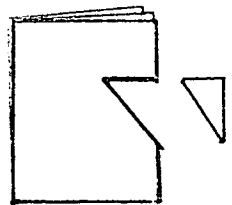
, B B

23.

A piece of paper is folded in half and then half again

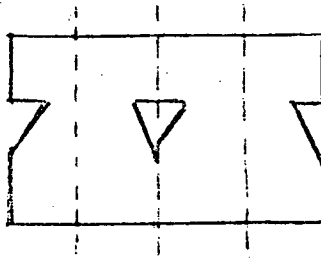


A triangle is then cut from the right hand edge:



The paper is unfolded and it looks like this:

23.



How many pairs of reflected triangles are there?

- (a) 0
- (b) 1
- (c) 2
- (d) 3
- (e) 4

Answer:

E

24.

Which one of the following shapes has a different area from the other three?

A



C



B



D

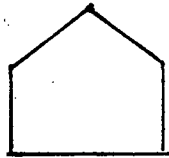


Answer :

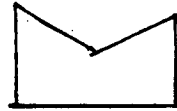
D

25. Draw a 5-sided plane shape that will tessellate.

eg.



or



See Appendix F.

---

26 The one of the following regular figures which can be made to enclose the largest area when inscribed in (drawn inside) the same circle is the;

(a) triangle

(b) square

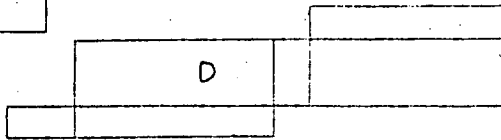
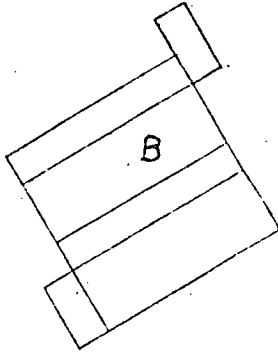
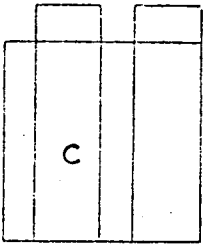
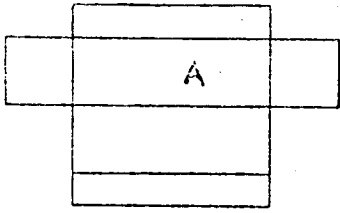
(c) rectangle

(d) pentagon

(e) hexagon

Answer: E

- 27 Which of the following nets can be folded to form a closed rectangular box?



Answer: D

28. A man waiting to use a telephone box walks up and down a footpath which runs east-west. Starting from the telephone box, he walked 5 metres east, 10 metres west, 15 metres east, and 20 metres west before the telephone box was vacant. How far must he now walk to reach the telephone box?

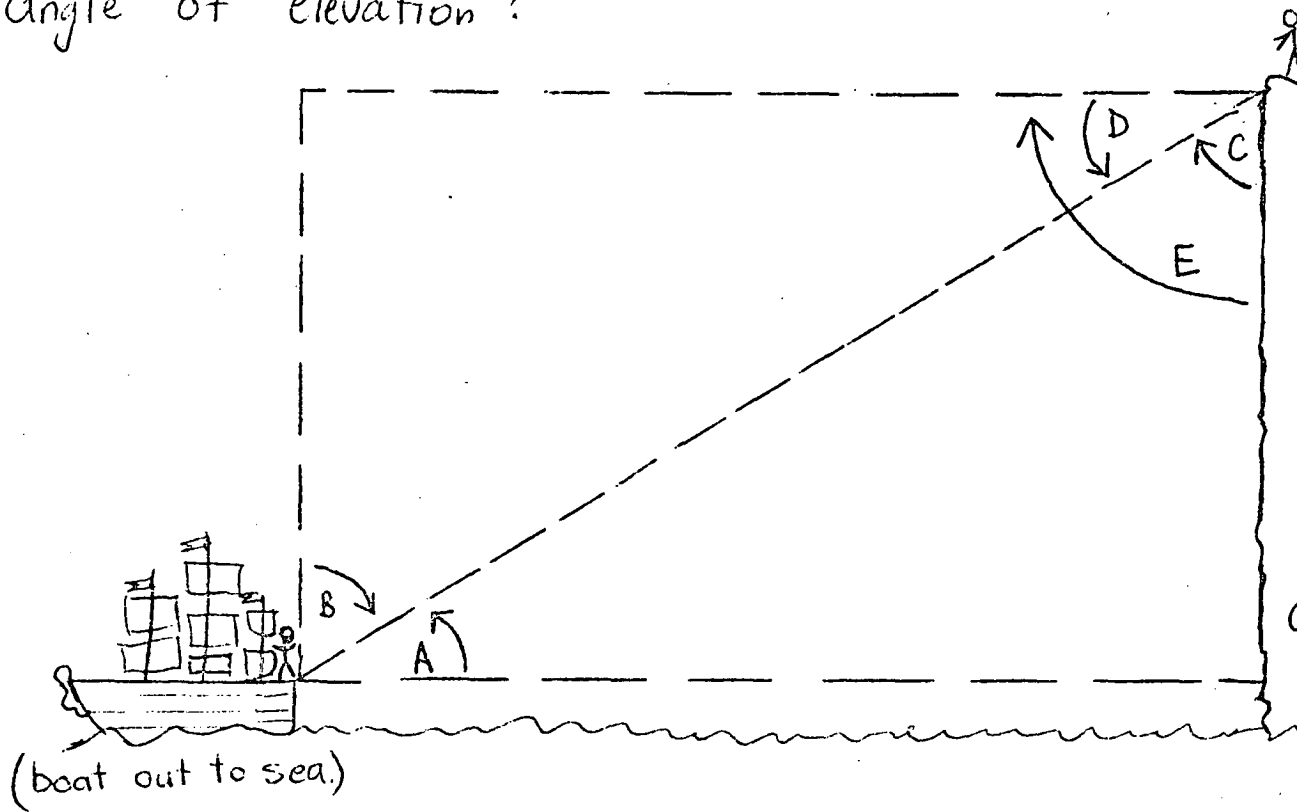
- (a) 5 metres west
- (b) 10 metres east
- (c) 10 metres west
- (d) 20 metres east
- (e) neither A, nor B, nor C, nor D.

Answer:

B



29. In the diagram below which letter stands for the angle of elevation?

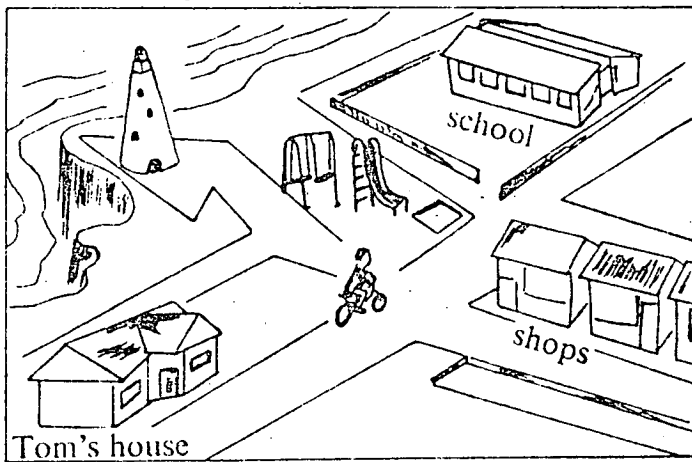


- (a) A
- (b) B
- (c) C
- (d) D
- (e) E

Answer: A

30.

Look at the picture below.



The shops are east of the lighthouse.  
 Tom's house is south of the playground.  
 Tom is riding to school.

The direction in which Tom is riding is

- (a) west
- (b) north
- (c) south
- (d) east

Answer: B

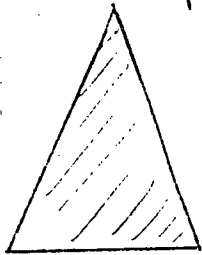
31. what is the latitude of the South Pole?

- (a)  $0^{\circ}\text{S}$
- (b)  $22\frac{1}{2}^{\circ}\text{S}$
- (c)  $45^{\circ}\text{S}$
- (d)  $67\frac{1}{2}^{\circ}\text{S}$
- (e)  $90^{\circ}\text{S}$

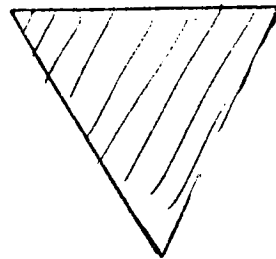
Answer: E

32. which one of the following could not be the shadow projection of a cone?

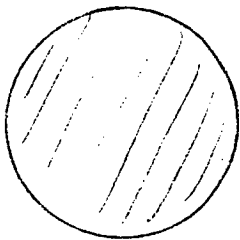
a)



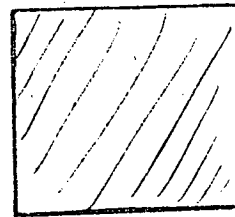
b)



c)

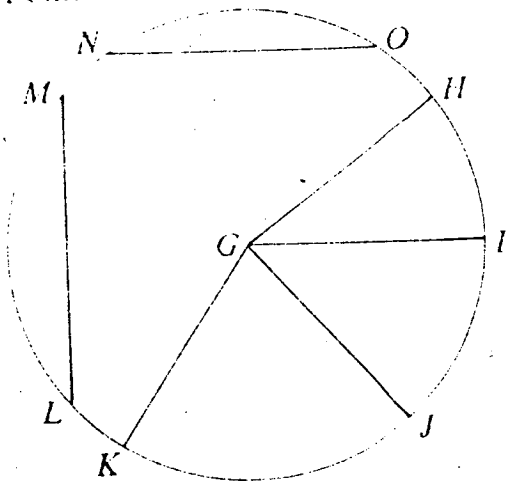


d)



Answer: D

33. Point  $G$  is the centre of the circle.



How many line segments **must** be equal in length in the above drawing?

A 6

B 2

C 4

D There is no way of telling.

Answer: C

34. Give an example of a parabola or of parabolic motion in nature.

See Appendix F.

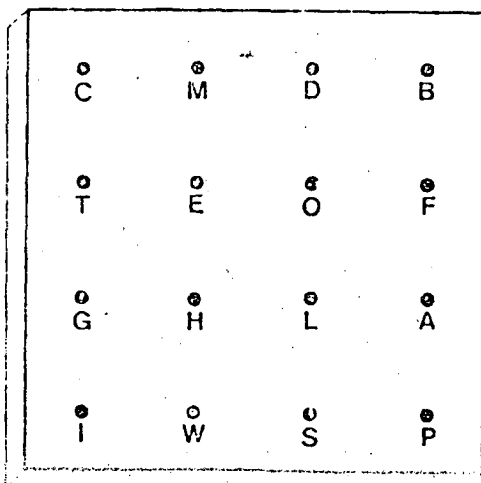
35. An angle measures  $30^\circ$ . The corresponding reflex angle is

- (a)  $30^\circ$
- (b)  $60^\circ$
- (c)  $150^\circ$
- (d)  $330^\circ$
- (e) need more information.

Answer: D

36.

These letters represent pegs placed at equal intervals in rows and columns on the board. Triangles can be formed by stretching an elastic band around sets of three pegs.



Which one of the following triangles would be both rightangled and isosceles?

- A PIG
- B BIT
- C COW
- D WAM

Answer: C



Pilot Version

THE SPATIAL AWARENESS  
TRACING TEST : Form B

NAME : \_\_\_\_\_

1) Consider the speeds of the following 3 animals:

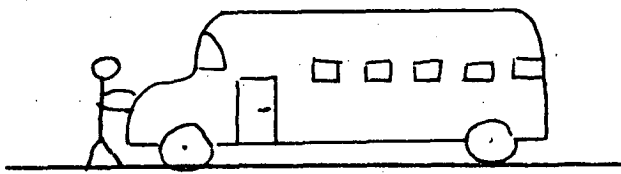
cow, kangaroo, tortoise

If they are arranged in order of increasing speed, the correct order is:

- (a) cow, kangaroo, tortoise
- (b) kangaroo, tortoise, cow
- (c) kangaroo, cow, tortoise
- (d) tortoise, cow, kangaroo
- (e) tortoise, kangaroo, cow

Answer: D

2) Which word, or phrase, best describes the position of the bus driver in relation to the bus?

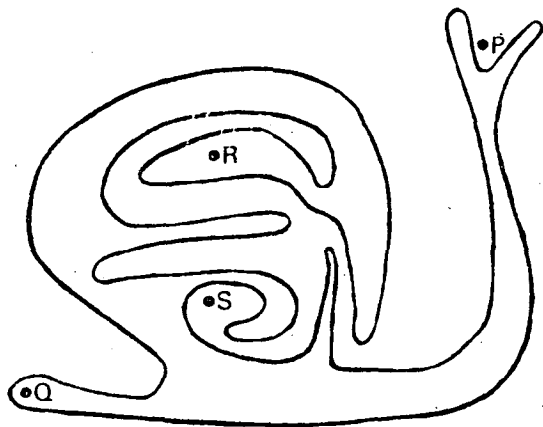


- (a) under
- (b) over
- (c) behind
- (d) away from
- (e) in front of

Answer: E

3/

For the simple closed curve illustrated, which point(s) are outside the curve?



A P only

C P and R

B P and Q

D P and S

Answer: D

4) Which one of the following has a shape MOST like an orange?

(a) cone

(b) cube

(c) cylinder

(d) sphere

(e) pyramid

Answer: D



5)

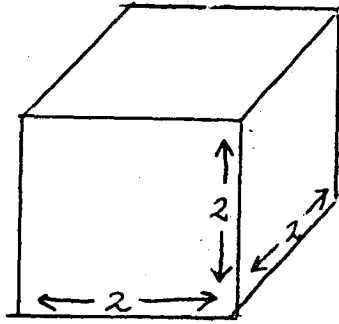


Figure 1 represents a :

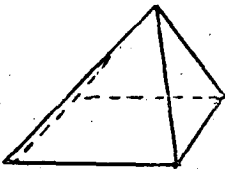
- (a) square
- (b) cube
- (c) square pyramid
- (d) hexagonal prism
- (e) trapezoid

Answer : B

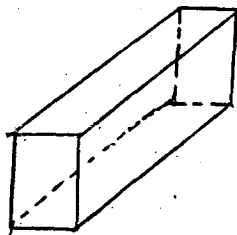
6)

(d) Which of the following is an example of a solid shape whose every face is a rectangle?

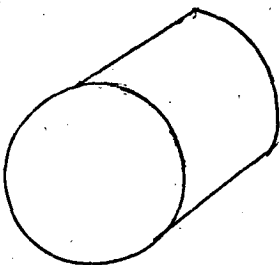
1.



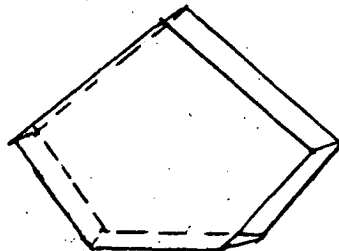
2.



3.



4.



- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) 2 and 4

Answer : B

7) There are 2 sets of attribute blocks: set A and set B. Set A contains only medium sized thin objects. Set B contains only thick circles. Which of the following is the best description of the intersection or overlap of A and B?

- (a) empty set.
- (b) medium sized circles.
- (c) thick and thin medium objects.
- (d) thick and thin circles.
- (e) thick objects.

Answer: A

This girl is looking through a lens at a caterpillar.

8)



She is holding the lens

- A in her left hand and up to her left eye.
- B in her left hand and up to her right eye.
- C in her right hand and up to her left eye.
- D in her right hand and up to her right eye.

Answer: B

---

9)

How many unit cubes would you need to put together to make another cube of edge 3 units?

- (a) 3
- (b) 8
- (c) 9
- (d) 12
- (e) 27

Answer: E

10)

Which of these 2D shapes repeated often enough will not completely cover a page?

- (a) square
- (b) rectangle
- (c) regular pentagon
- (d) regular hexagon
- (e) right angled triangle

Answer: C

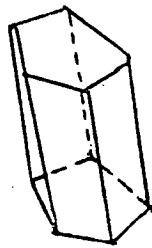
11)

All the faces of a pyramid except the base are: ?

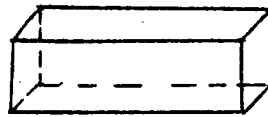
Answer: triangles

12)

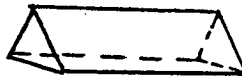
(1)



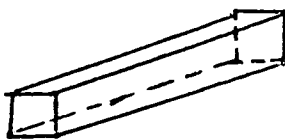
(2)



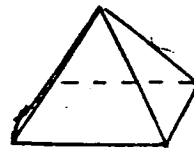
(3)



(4)



(5)



of the figures above the following show prisms

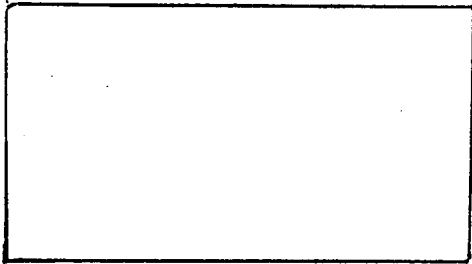
- (a) figure (5) only
- (b) figure (3) only
- (c) figures (1), (2), (3) and (4) only
- (d) figures (1), (2), (3), (4) and (5)
- (e) none of the above choices is correct.

Answer: C

13. What is a tessellation? Give an example.

See Appendix F.

14. How many axes of symmetry has a rectangle



- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) an infinite number

Answer: B

15. How many right angles are there on a cube (the edges of the cube forming the arms)?

(a) 8

(b) 12

(c) 16

(d) 18

(e) 24

Answer: E

16. In one week the hour hand of an electric clock goes round the face.

A twice

B 7 times

C 12 times

D 14 times

E 168 times

Answer: D

17 Consider a rectangular block of wood.

How many surfaces or faces has it? 6

How many edges has it? 12

How many corners has it? 8

18. Which of the following is the best example of vertical?

- (a) a window sill
- (b) a tumbledown pioneer cottage.
- (c) a telegraph pole
- (d) a map of Tasmania
- (e) a chalk box

Answer : C

19 How many pairs of parallel edges are there in a cube?

Answer : 18



20. Which of the following is the best example of a cylinder?

- (a) a chair
- (b) a cardboard carton
- (c) a water pipe
- (d) a chalk box
- (e) the blackboard

Answer: C

---

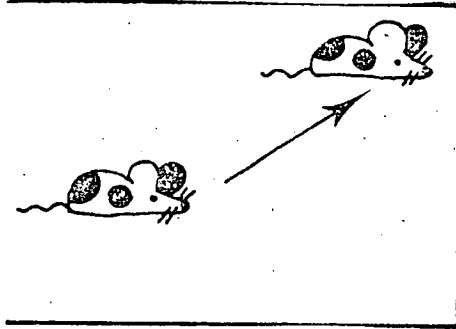
21. How many lines of rotational symmetry does a circle have?

- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) infinite

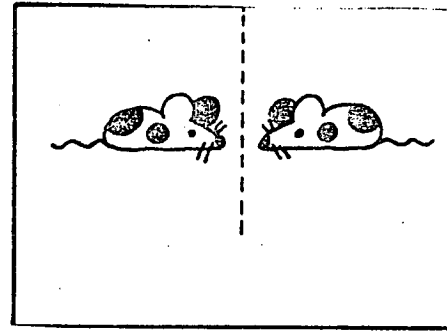
Answer: E

22. The diagrams show two types of movement

I



II



The type of movement in  
I is :

- (a) rotation
- (b) reflection
- (c) translation
- (d) none of these

and in II is :

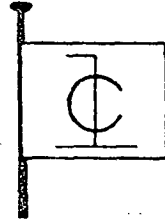
- (a) rotation
- (b) reflection
- (c) translation
- (d) none of these

Answer : I C

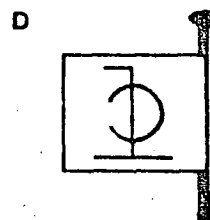
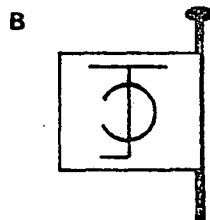
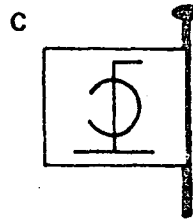
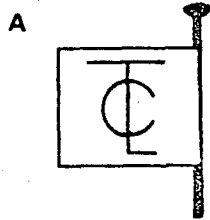
II B

23

This pattern has been woven right through the fabric of a flag which is blowing in a strong wind.



Which one of the following shows how the flag would look when the wind changes to the opposite direction?



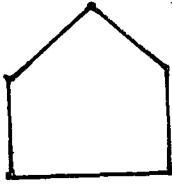
Answer: C

24. In the space below construct a small grid and draw a triangle with area 3 square units.

See Appendix F.

- 25 Draw a 5-sided plane shape that will tessellate

e.g.



or

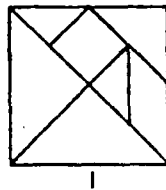


See Appendix F.

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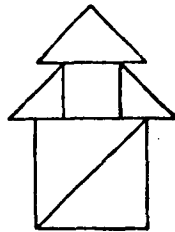
A tangram consists of seven geometric shapes formed by cutting up a square as shown.

26.

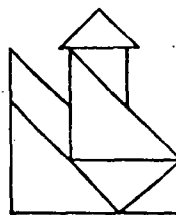


Which one of the following designs can be made by using all of the tangram pieces in Figure 1?

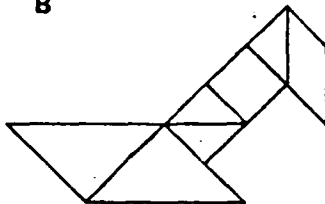
A



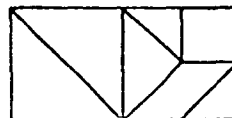
C



B

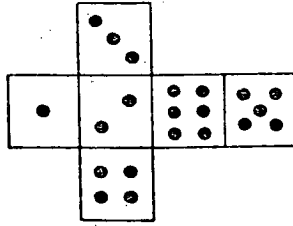


D

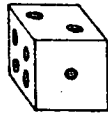


Answer: D

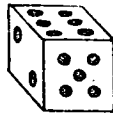
This pattern was drawn on cardboard, then cut and folded to make a hollow die.



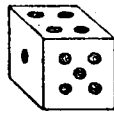
Which one of the following shows a view of the die so formed?



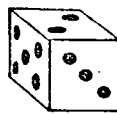
A



B



C



D

Answer: C

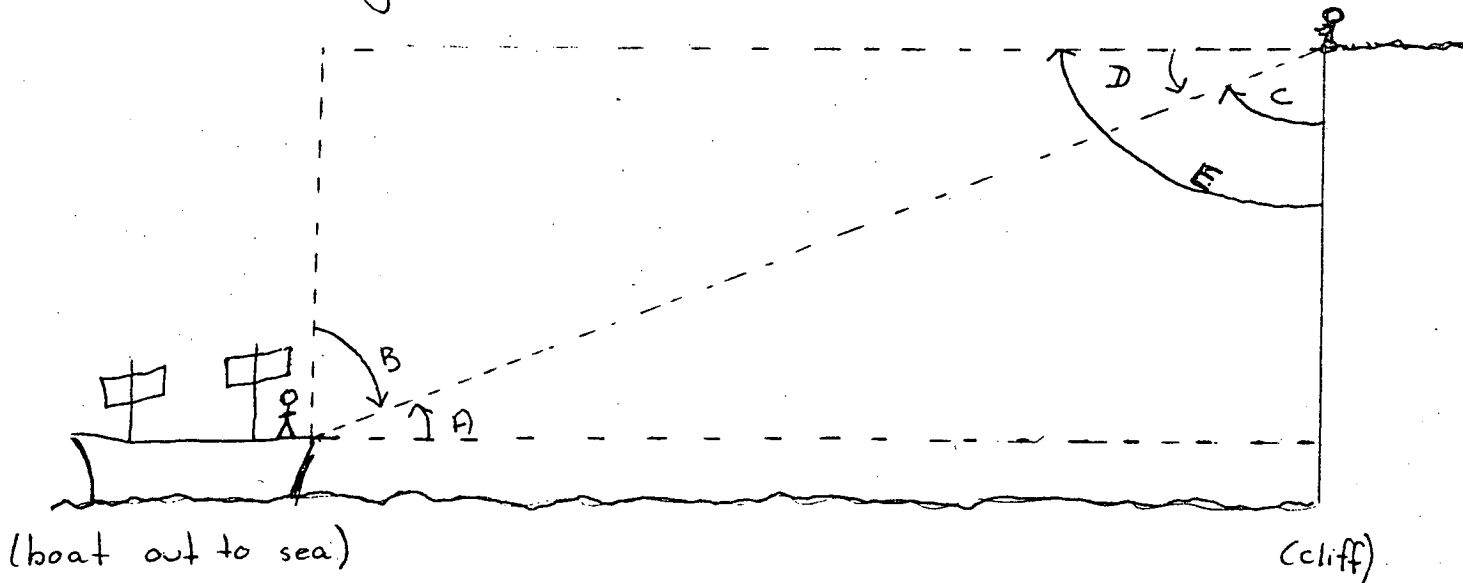
28

Margaret stands on a hilltop facing due north, then turns in a clockwise direction until she faces south-west. Through what angle has she turned?

A  $135^\circ$ C  $225^\circ$ B  $180^\circ$ D  $270^\circ$ 

Answer: C

29. In the diagram below which letter stands for the angle of elevation?

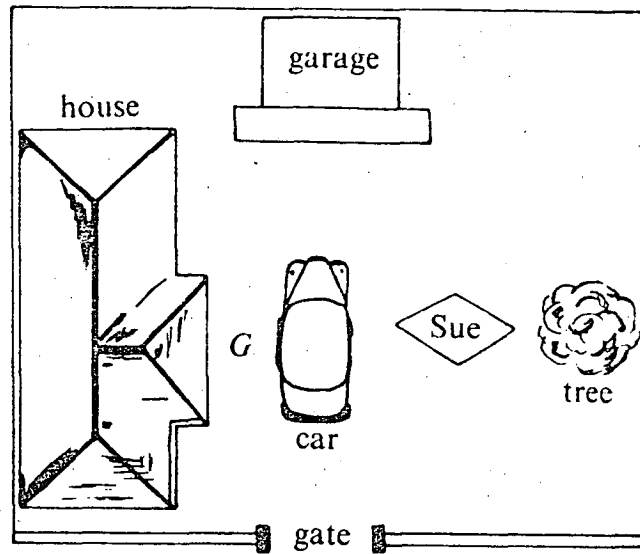


- (a) A
- (b) B
- (c) C
- (d) D
- (e) E

Answer: A

30.

Look at the picture below.



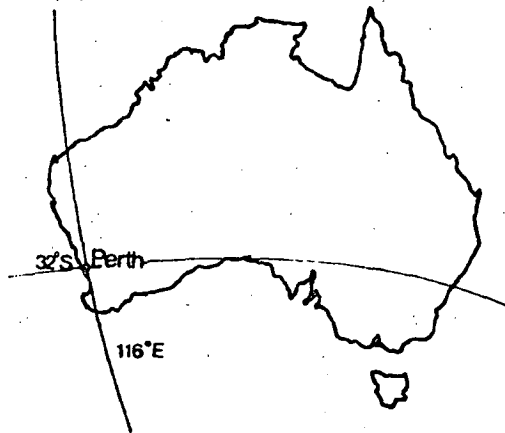
Sue walks around the car and stands at position *G* facing the gate. What is on Sue's left-hand side?

- A the house and car
- B the tree and car
- C the tree only
- D the garage

Answer: B

31

Perth has a latitude  $32^\circ$  South and a longitude  $116^\circ$  East. Bermuda is directly opposite Perth on the earth's spherical surface.



The latitude and longitude of Bermuda must be

- A  $32^\circ\text{S } 116^\circ\text{W}$ .
- B  $32^\circ\text{N } 116^\circ\text{W}$ .
- C  $32^\circ\text{S } 64^\circ\text{W}$ .
- D  $32^\circ\text{N } 64^\circ\text{W}$ .

Answer: D

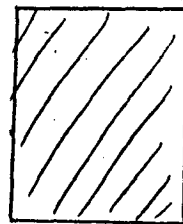
32

Which one of the following could not be the shadow projection of a cube?

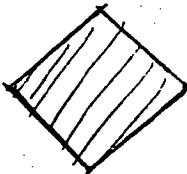
1)



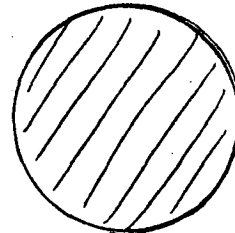
2)



3)



4)

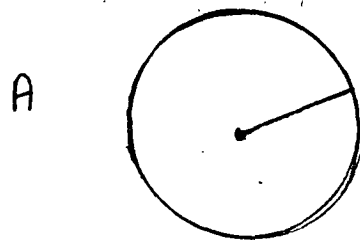


- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) more than 1 of the above

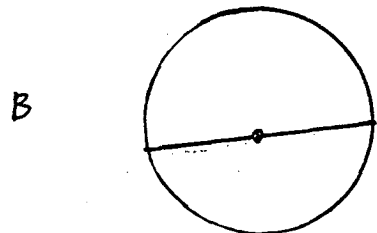
Answer: D



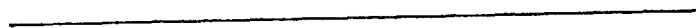
33 In circle A draw a radius



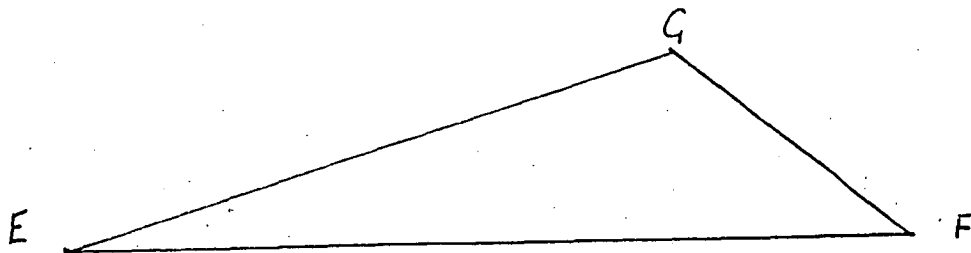
In circle B draw a diameter



34 Give an example of a parabola or parabolic motion in nature.



35

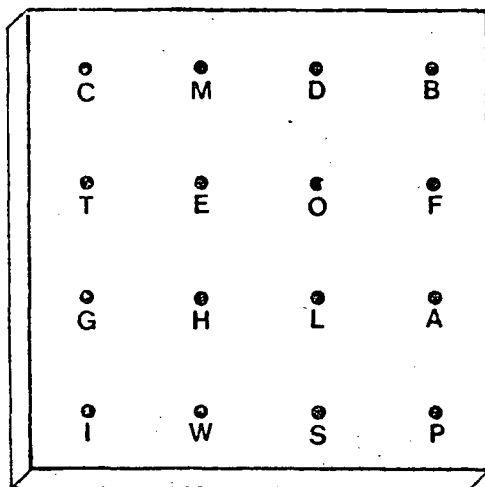


If the measure of Angle F is  $50^\circ$  and the measure of Angle G is  $105^\circ$ , what is the measure of Angle E?

Answer:  $25^\circ$

36

These letters represent pegs placed at equal intervals in rows and columns on the board. Triangles can be formed by stretching an elastic band around sets of three pegs.



Which one of the following triangles would be both rightangled and isosceles?

- |   |     |   |     |
|---|-----|---|-----|
| A | PIG | C | COW |
| B | BIT | D | WAM |

Answer: C

ADDITIONAL COMMENTS.

Appendix E

SATT (Final Version) and Questionnaires

## **THE SPATIAL AWARENESS TEACHING TEST**

### **FORM A**

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**STRICTLY CONFIDENTIAL**

Your answers to these questions, and the following Spatial Awareness questions, are strictly confidential.

NAME: .....

SEX (tick the correct one):      Female/Male

AGE (tick the correct one):      20-24/25-29/30-34/35-39/40-44/45-49/50-54/55-59/60-65

AT WHAT INSTITUTION DID YOU DO YOUR INITIAL TEACHER TRAINING? .....

.....

FOR HOW MANY YEARS WAS YOUR INITIAL TEACHER TRAINING? .....

HAVE YOU UPGRADED, OR ARE YOU CURRENTLY UPGRADING, YOUR TEACHING QUALIFICATIONS?  
(tick the correct one):      No/Yes

If Yes, give details. ....

.....

FOR HOW MANY YEARS HAVE YOU BEEN TEACHING? .....

DO YOU HAVE FULL-TIME RESPONSIBILITY FOR A CLASS? (tick the correct one):      No/Yes

If YES, what grade do you currently teach? .....

(If you teach a composite class, just indicate the grade that has the most children).

If NO indicate which of Librarian, Infant Mistress, Senior Teacher, Principal, etc. you are. ....

WHICH AREA OF TEACHING IN THE INFANT OR PRIMARY SCHOOL ARE YOU MOST INTERESTED IN?

- (Tick one)      Infant (Grades K - 2)  
                     Middle Primary (Grades 3 and 4)  
                     Upper Primary (Grades 5 and 6)

TO WHAT LEVEL DID YOU STUDY MATHEMATICS IN THE SECONDARY SCHOOL? (tick the correct one)

year 7 / 8 / 9 / 10 / 11 / 12

Thank you for your co-operation. Please return this questionnaire to

The Spatial Abilities and Spatial Awareness Project,  
 c/- Department of Educational Studies,  
 Centre for Education,  
 University of Tasmania,  
 G.P.O. Box 252C,  
 HOBART, Tas 7001.

(Please tick this box ☐ if you would like to know of your result in this test.)

## **THE SPATIAL AWARENESS TEACHING TEST**

### **FORM B**

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NAME: .....

SEX (tick the correct one):      Female/Male

AGE (tick the correct one):      20-24/25-29/30-34/35-39/40-44/45-49/50-54/55-59/60-65

AT WHAT INSTITUTION DID YOU DO YOUR INITIAL TEACHER TRAINING? .....

FOR HOW MANY YEARS WAS YOUR INITIAL TEACHER TRAINING? .....

HAVE YOU UPGRADED, OR ARE YOU CURRENTLY UPGRADING, YOUR TEACHING QUALIFICATIONS?  
(tick the correct one):      No/Yes

If Yes, give details. ....

FOR HOW MANY YEARS HAVE YOU BEEN TEACHING? .....

DO YOU HAVE FULL-TIME RESPONSIBILITY FOR A CLASS? (tick the correct one):      No/Yes

If YES, what grade do you currently teach? .....

(If you teach a composite class, just indicate the grade that has the most children).

If NO indicate which of Librarian, Infant Mistress, Senior Teacher, Principal, etc. you are. ....

WHICH AREA OF TEACHING IN THE INFANT OR PRIMARY SCHOOL ARE YOU MOST INTERESTED IN?

- (Tick one)      Infant (Grades K - 2)  
                     Middle Primary (Grades 3 and 4)  
                     Upper Primary (Grades 5 and 6)

TO WHAT LEVEL DID YOU STUDY MATHEMATICS IN THE SECONDARY SCHOOL? (tick the correct one)

year 7 / 8 / 9 / 10 / 11 / 12

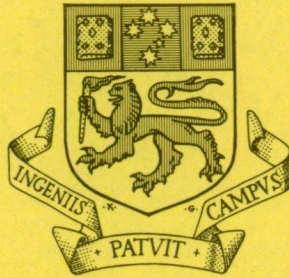
Thank you for your co-operation. Please return this questionnaire to

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c/- Department of Educational Studies,  
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University of Tasmania,  
G.P.O. Box 252C,  
HOBART, Tas 7001.

(Please tick this box ☐ if you would like to know of your result in this test.)



***Strictly Confidential***



**THE SPATIAL ABILITIES  
AND  
SPATIAL AWARENESS PROJECT**

**CENTRE FOR EDUCATION  
UNIVERSITY OF TASMANIA**

**STRICTLY CONFIDENTIAL**

Your answers to these questions, and the following Spatial Awareness questions, are strictly confidential.

NAME: .....

SEX (tick the correct one): Female/Male

IN WHAT YEAR OF YOUR COURSE ARE YOU NOW? (tick the correct one): I / II / III / IV

TEACHER TRAINING INSTITUTION (tick the correct one):

T.C.A.E., Newnham/Centre for Education, Uni. of Tas.

DATE OF BIRTH: month....., year .....

PROPOSED TEACHING AREA ( tick the correct one): Infant/Primary/Secondary

If Secondary, list your proposed teaching subjects. ....

.....

WHAT ARE YOUR TWO MAJOR ELECTIVE STUDIES ? (tick the correct ones):

English/Social Science/Science/Mathematics/Art/Craft/Home Economics/ etc. (please list any other(s)

....., .....

TO WHAT LEVEL DID YOU STUDY MATHEMATICS IN THE SECONDARY SCHOOL (tick the correct one):

year 7 / 8 / 9 / 10 / 11 / 12

Thank you for your co-operation. Please return this questionnaire to

The Spatial Abilities and Spatial Awareness Project,  
c/- Department of Educational Studies  
Centre for Education,  
University of Tasmania,  
G.P.O. Box 252C,  
HOBART, Tas 7001.

(Please tick this box ☐ if you would like to know of your result in this test.)

## THE SPATIAL AWARENESS TEACHING TEST

### FORM A

NAME: \_\_\_\_\_

SCHOOL: \_\_\_\_\_

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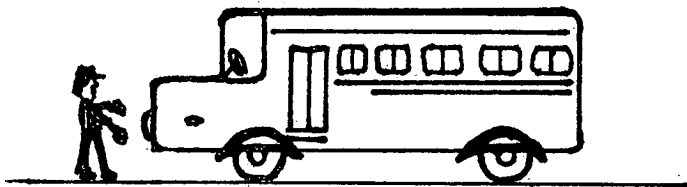
1. Which of the sets of adjectives listed below best corresponds in order to the movement verbs SPRINT, WALK, JOG?

- (a) fast, slow, medium
- (b) slow, medium, fast
- (c) medium, fast, slow
- (d) slow, fast, medium
- (e) medium, slow, fast

Answer:

**A**

2. Which word or phrase best describes the position of the bus driver in relation to the bus?

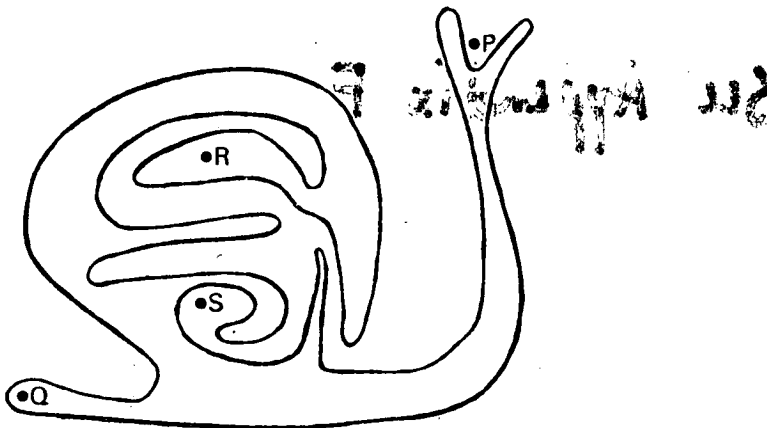


- (a) under
- (b) over
- (c) behind
- (d) away from
- (e) in front of

Answer:

**E**

3. For the simple closed curve illustrated, which point(s) are outside the curve?



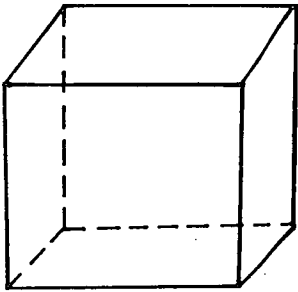
- (a) P only
- (b) P and Q
- (c) P and R
- (d) P and S

Answer:

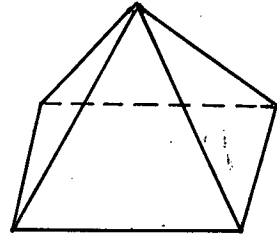
**D**

Questions 4, 5 and 6 relate to these four solids.

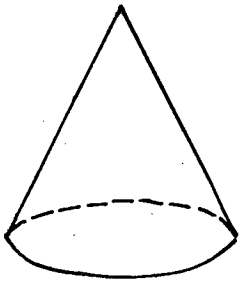
1)



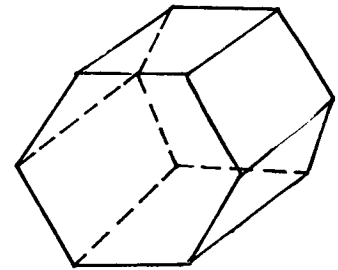
2)



3)



4)



4. Name the four solids.

1)

cube

2)

pyramid

3)

cone

4)

hexagonal prism

5. Describe two sets into which the solids could be divided. Indicate by numbers which solids you would put into each set.

Description: \_\_\_\_\_

See Appendix F

Solid numbers: \_\_\_\_\_ &amp; \_\_\_\_\_

6. Describe *another* 2 sets into which the solids could be divided. Indicate by numbers which solids you would put into each set.

Description: \_\_\_\_\_

See Appendix F

Solid numbers: \_\_\_\_\_ &amp; \_\_\_\_\_



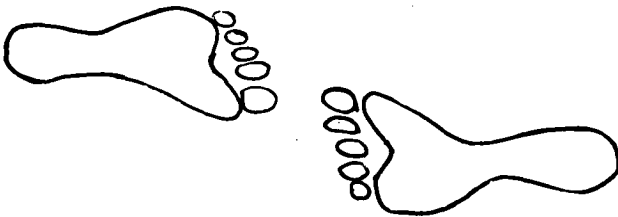
7. There are 2 sets of attribute blocks, set A and set B. Set A contains only medium sized thin objects. Set B contains only thick circles. Which of the following is the best description of the intersection, or overlap, of A and B?

- (a) empty set
- (b) medium sized circles
- (c) thick and thin medium objects
- (d) thick and thin circles
- (e) thick objects

Answer:

**A**

8. These two foot prints were seen on the sand.



They were made by

- (a) a left foot and a right foot
- (b) two left feet
- (c) two right feet
- (d) none of the above.

Answer:

**B**

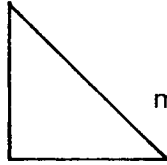
9. A large square has the length of one of its edges twice as long as the edge of another square. How many smaller squares are needed to cover the larger?

- (a) 2
- (b) 3
- (c) 4
- (d) 8
- (e) Can't tell without a measurement for the two squares.

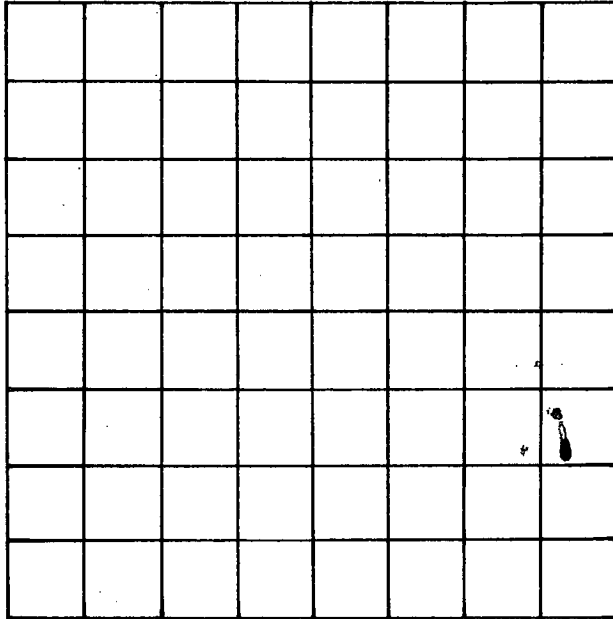
Answer:

**C**

10. Using this triangle



make a pattern which will completely fill up the square.



See Appendix F

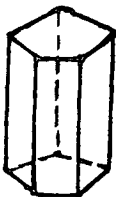
11. How many squares are there on the surface of a cube?

- (a) 1
- (b) 4
- (c) 6
- (d) 9
- (e) 16

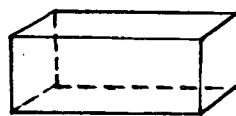
C

Answer:

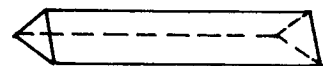
12. (1)



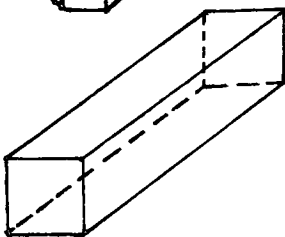
(2)



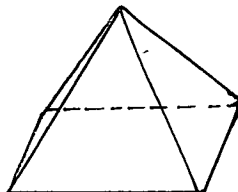
(3)



(4)



(5)



Of the figures above the following show prisms:

- (a) figure (5) only
- (b) figure (3) only
- (c) figures (1), (2), (3) and (4) only
- (d) figures (1), (2), (3), (4) and (5)
- (e) none of the above choices is correct.

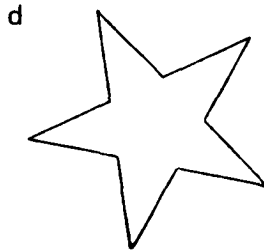
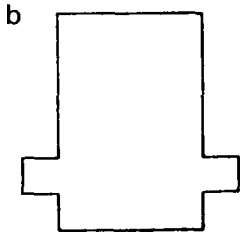
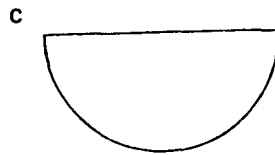
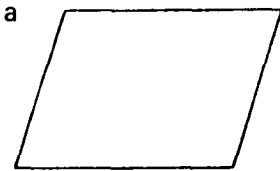
Answer:

C

13. In a sentence or two, describe what a tessellation is. As well, draw an example.

See Appendix F

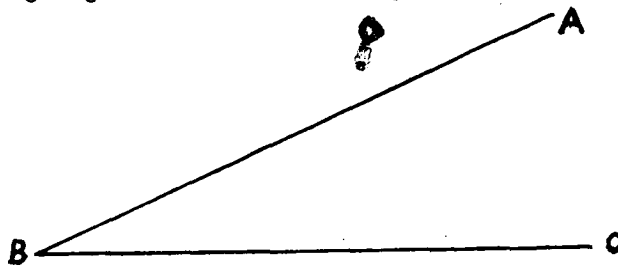
14. Which one of the following shapes has no axes of symmetry?



Answer:

A

15. Consider the following diagram:



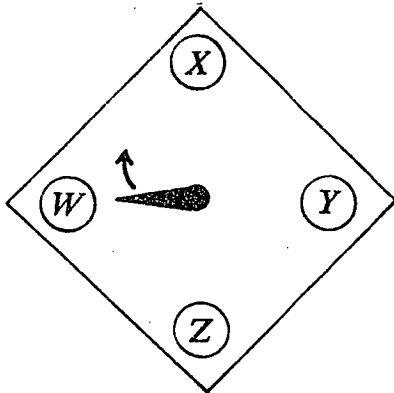
In what way do the lengths of AB and BC affect the measure of angle B?

Answer:

NO AFFECT



16. Look at the picture below.



7 xibndyga 332

The pointer turns **only** in the direction shown by the arrow. When the pointer is turned from *W* all the way round to *W* again it has made a complete turn.

The pointer is pointing towards *W*. If turned three quarters of a turn the pointer will be pointing towards

- (a) *X*
- (b) *Y*
- (c) *Z*
- (d) *W*.

C

Answer:

17. Consider a rectangular block of wood.

6

A

How many surfaces or faces has it? \_\_\_\_\_

12

How many edges has it? \_\_\_\_\_

8

How many corners has it? \_\_\_\_\_

18. Which of the following is the best example of *horizontal*?

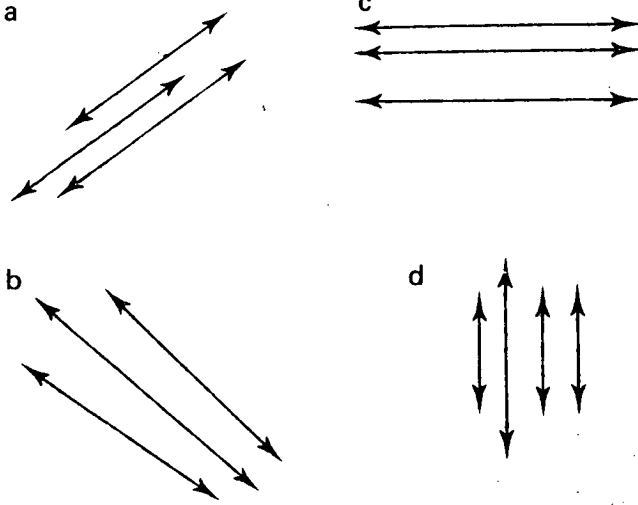
- (a) the side of a hill
- (b) the surface of a calm pond
- (c) the side of a tall building
- (d) a car wheel
- (e) a slippery dip

NO AFFERT

Answer:

B

19. Which one of the following is a group of lines which are **not** parallel?



Answer:

**B**

20. A circle has a radius the same length as the side of a square. How many squares will fit inside the circle without overlapping?

- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) cannot tell without the length of the radius and/or the side of the square.

Answer:

**A**

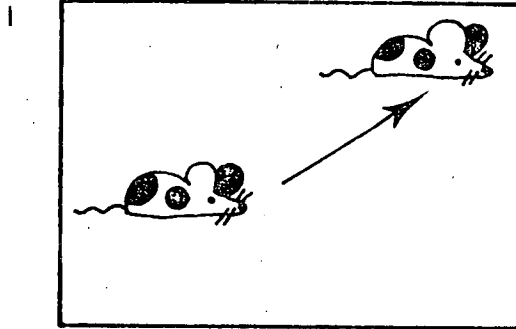
21. How many lines of rotational symmetry does a circle have?

- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) infinite

Answer:

**E**

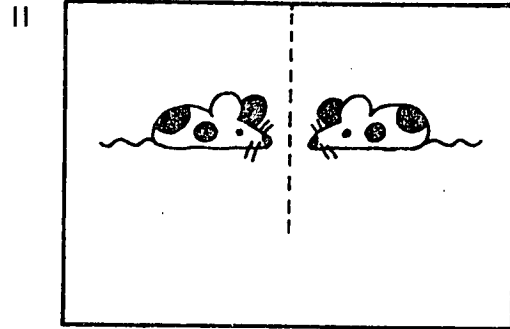
22. The diagrams show two types of movement.



The type of movement in I is:

- (a) rotation
- (b) reflection
- (c) translation
- (d) none of these.

Answer: I     C    

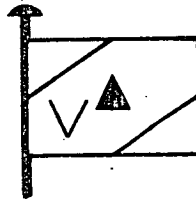


The type of movement in II is:

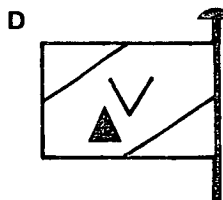
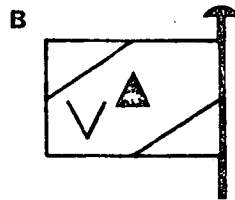
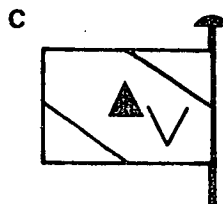
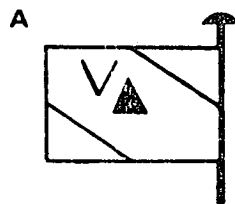
- (a) rotation
- (b) reflection
- (c) translation
- (d) none of these.

II     B    

23. This pattern has been woven right through the fabric of a flag which is blowing in a strong wind.

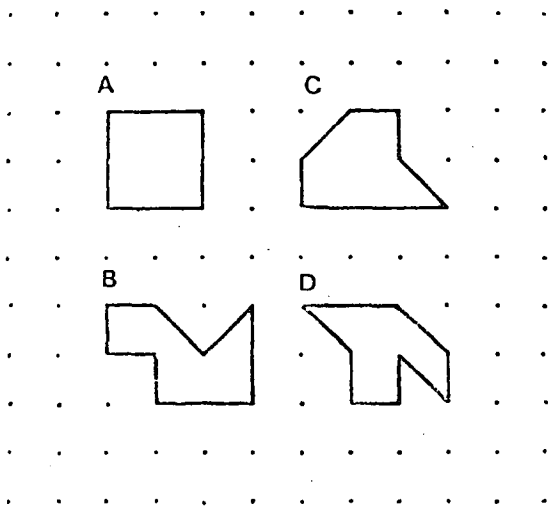


Which one of the following shows the flag when the wind changes to the opposite direction?



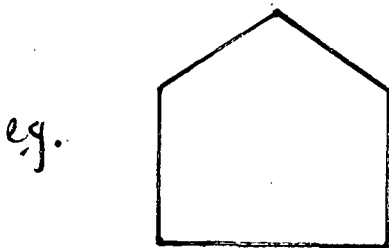
Answer:     C

24. Which one of the following shapes has a different area from the other three?

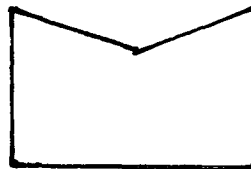


Answer: **D**

25. Draw a 5-sided plane shape that will tessellate.



or



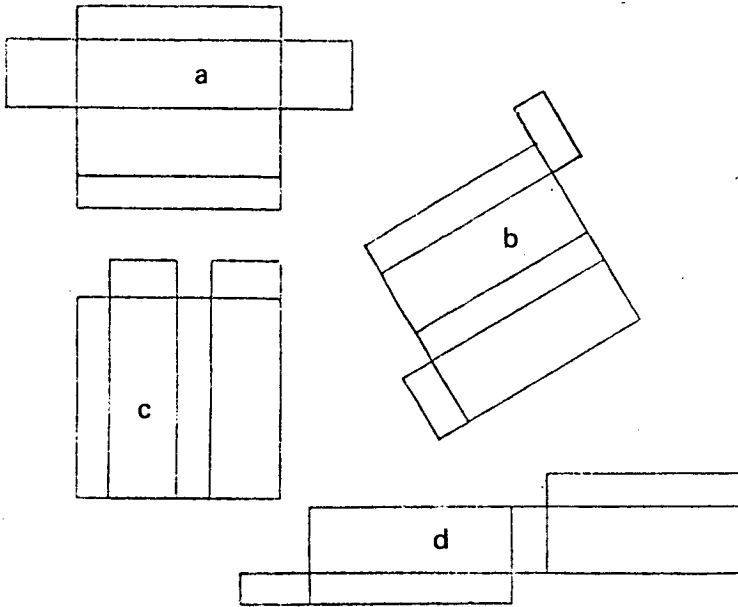
See Appendix F

26. Which one of the following regular figures can be made to enclose the largest area when inscribed in (drawn inside) the same circle?

- (a) triangle
- (b) square
- (c) rectangle
- (d) pentagon
- (e) hexagon

Answer: **E**

27. Which of the following nets can be folded to form a closed rectangular box?



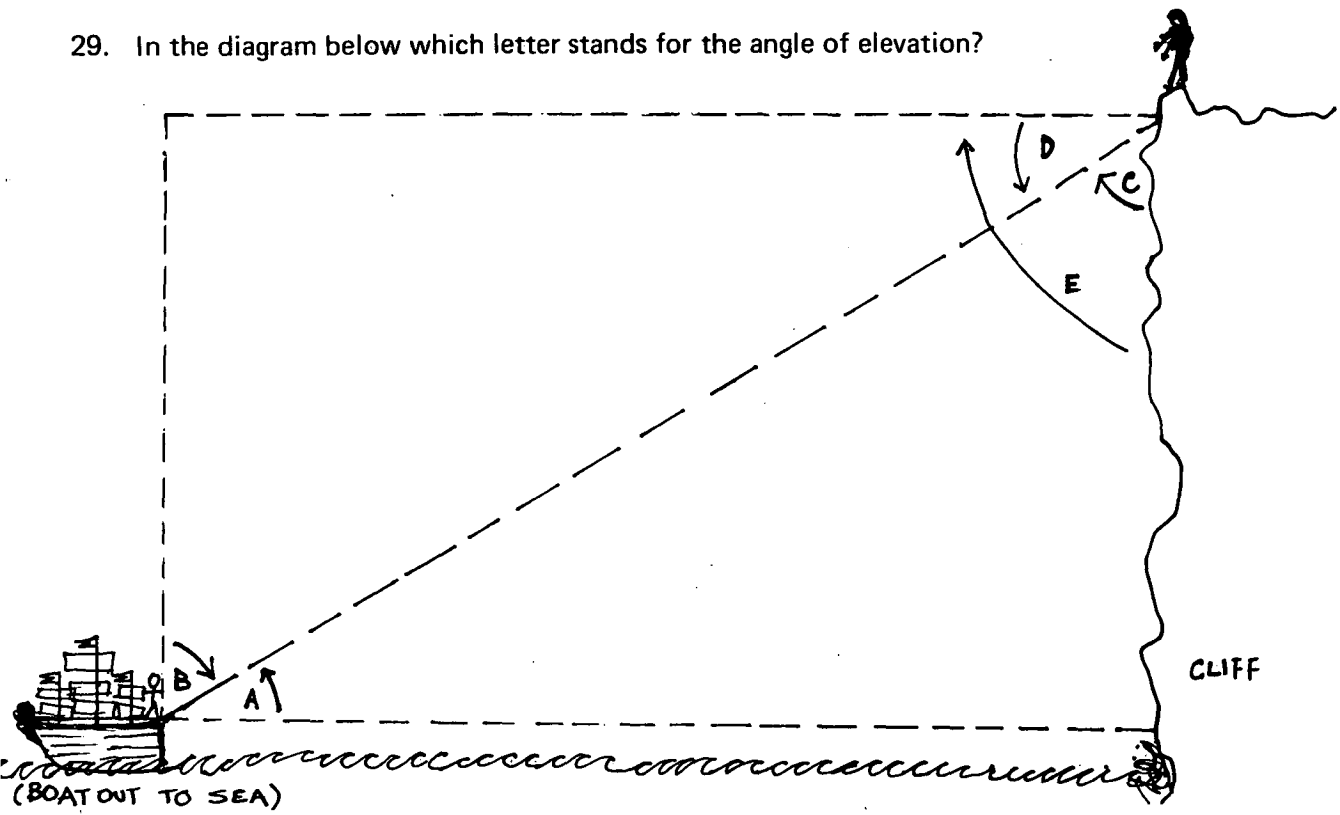
Answer: D

28. A man waiting to use a telephone box walks up and down a footpath which runs east-west. Starting from the telephone box, he walked 5 metres east, 10 metres west, 15 metres east, and 20 metres west before the telephone box was vacant. How far must he now walk to reach the telephone box?

- (a) 5 metres west
- (b) 10 metres east
- (c) 10 metres west
- (d) 20 metres east
- (e) neither A, nor B, nor C, nor D.

Answer: B

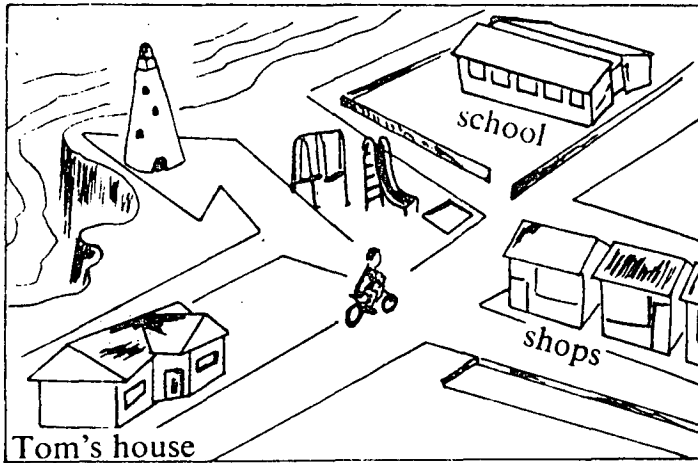
29. In the diagram below which letter stands for the angle of elevation?



- (a) A
- (b) B
- (c) C
- (d) D
- (e) E

Answer: A

30. Look at the picture below.



The shops are east of the lighthouse.  
 Tom's house is south of the playground.  
 Tom is riding to school.

The direction in which Tom is riding is

- (a) west
- (b) north
- (c) south
- (d) east

Answer:

B

31. What is the latitude of the South Pole?

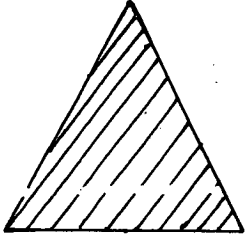
- (a)  $0^{\circ}\text{S}$
- (b)  $22\frac{1}{2}^{\circ}\text{S}$
- (c)  $45^{\circ}\text{S}$
- (d)  $67\frac{1}{2}^{\circ}\text{S}$
- (e)  $90^{\circ}\text{S}$

Answer:

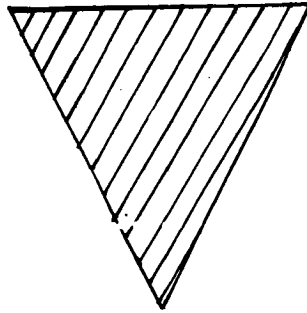
E

32. Which of the following could not be the shadow projection of a cone?

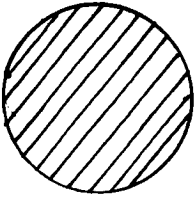
1)



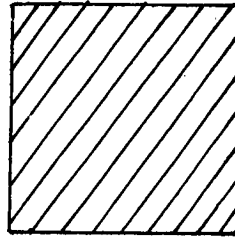
2)



3)



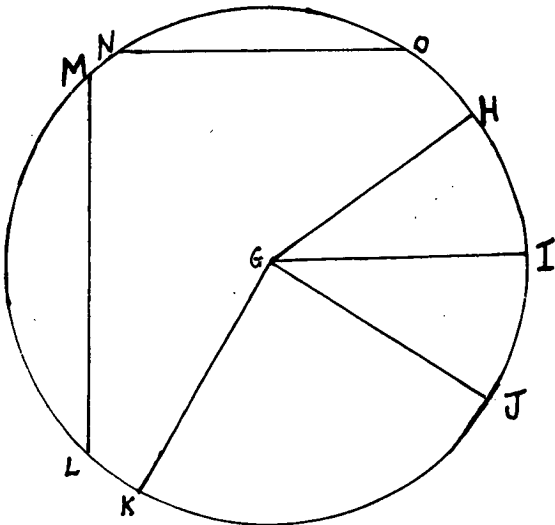
4)



- (a) 1  
 (b) 2  
 (c) 3  
 (d) 4  
 (e) more than one of the above.

Answer: D

33. Point  $G$  is the centre of the circle.



How many line segments **must** be equal in length in the above drawing?

- (a) 6  
 (b) 2  
 (c) 4  
 (d) There is no way of telling.

Answer: C



34. Give an example of a *parabola* or of *parabolic motion* in nature.

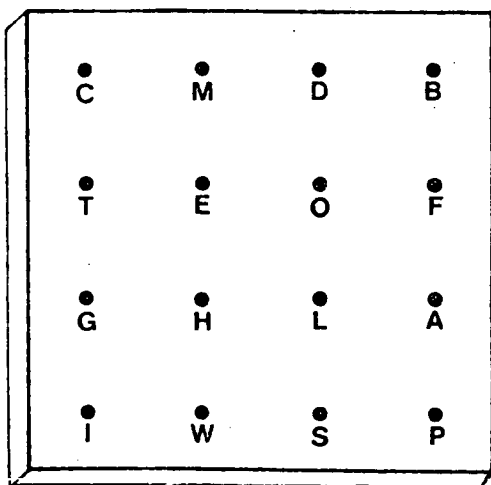
See Appendix F

35. An angle measures  $30^\circ$ . The corresponding *reflex* angle is

- (a)  $30^\circ$
- (b)  $60^\circ$
- (c)  $150^\circ$
- (d)  $330^\circ$
- (e) need more information.

Answer: D

36. These letters represent pegs placed at equal intervals in rows and columns on the board. Triangles can be formed by stretching an elastic band around sets of three pegs.



Which one of the following triangles would be both rightangled and isosceles?

- (a) PIG
- (b) BIT
- (c) COW
- (d) WAM

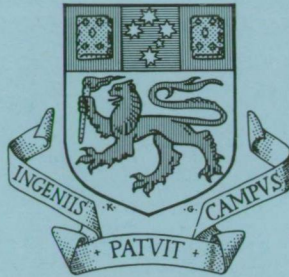
Answer: C

## COMMENTS

If there is any comment you wish to make on the test as a whole or on individual items feel free to do so.



***Strictly Confidential***



**THE SPATIAL ABILITIES  
AND  
SPATIAL AWARENESS PROJECT**

**CENTRE FOR EDUCATION  
UNIVERSITY OF TASMANIA**

**STRICTLY CONFIDENTIAL**

Your answers to these questions, and the following Spatial Awareness questions, are strictly confidential.

NAME: .....

SEX (tick the correct one): Female/Male

IN WHAT YEAR OF YOUR COURSE ARE YOU NOW? (tick the correct one): I / II / III / IV

TEACHER TRAINING INSTITUTION (tick the correct one):

T.C.A.E., Newnham/Centre for Education, Uni. of Tas.

DATE OF BIRTH: month....., year .....

PROPOSED TEACHING AREA ( tick the correct one): Infant/Primary/Secondary

If Secondary, list your proposed teaching subjects. ....

.....

WHAT ARE YOUR TWO MAJOR ELECTIVE STUDIES ? (tick the correct ones):

English/Social Science/Science/Mathematics/Art/Craft/Home Economics/ etc. (please list any other(s)

....., .....

TO WHAT LEVEL DID YOU STUDY MATHEMATICS IN THE SECONDARY SCHOOL (tick the correct one):

year 7 / 8 / 9 / 10 / 11 / 12

Thank you for your co-operation. Please return this questionnaire to

The Spatial Abilities and Spatial Awareness Project,  
c/- Department of Educational Studies  
Centre for Education,  
University of Tasmania,  
G.P.O. Box 252C,  
HOBART, Tas 7001.

(Please tick this box ☐ if you would like to know of your result in this test.)

## THE SPATIAL AWARENESS TEACHING TEST

### FORM B

NAME: \_\_\_\_\_

SCHOOL: \_\_\_\_\_

A number of items in this test are reprinted by permission of The Australian Council for Educational Research Limited. Copyright on the following items is held by ACER: 3, 5, 8, 16, 22, 23, 26, 27, 28, 30, 31, 36.

1. Consider the speeds of the following 3 animals:

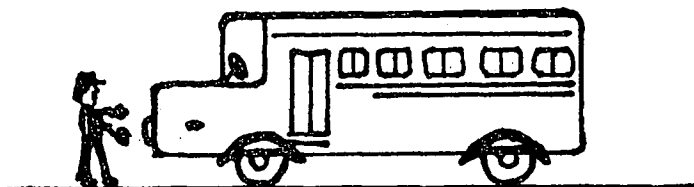
cow, kangaroo, tortoise.

If they are arranged in order of increasing speed, the correct order is:

- (a) cow, kangaroo, tortoise
- (b) kangaroo, tortoise, cow
- (c) kangaroo, cow, tortoise
- (d) tortoise, cow, kangaroo
- (e) tortoise, kangaroo, cow.

Answer: D

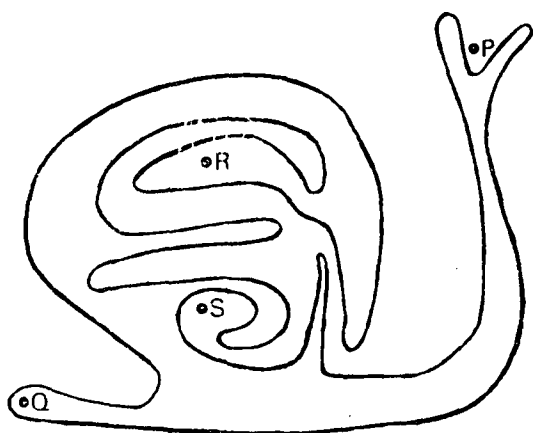
2. Which word or phrase best describes the position of the bus driver in relation to the bus?



- (a) under
- (b) over
- (c) behind
- (d) away from
- (e) in front of

Answer: E

3. For the simple closed curve illustrated, which point(s) are outside the curve?



- (a) P only
- (b) P and Q
- (c) P and R
- (d) P and S

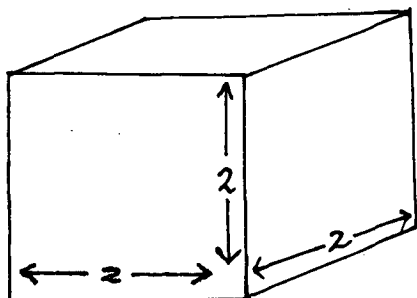
Answer: D

4. Which one of the following has a shape *most* like an orange?

- (a) cone
- (b) cube
- (c) cylinder
- (d) sphere
- (e) pyramid

Answer: D

5.



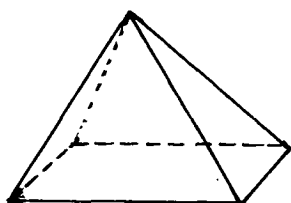
This figure represents a:

- (a) square
- (b) cube
- (c) square pyramid
- (d) hexagonal prism
- (e) trapezoid.

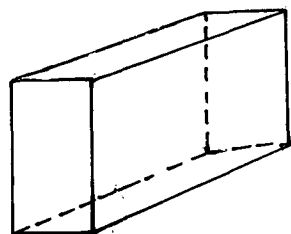
Answer: B

6. Which of the following is an example of a solid shape whose every face is a rectangle?

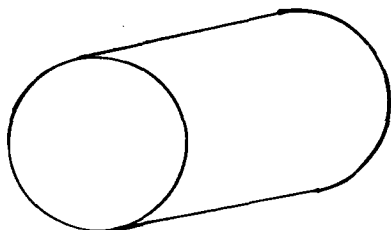
1.



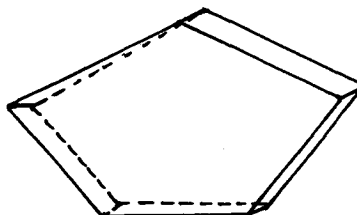
2.



3.



4.



(a) 1

(b) 2

(c) 3

(d) 4

(e) more than one of the above.

Answer: B

10. Which of these 2D shapes repeated often enough will not completely cover a page?

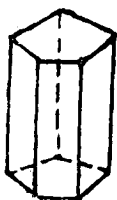
- (a) square
- (b) rectangle
- (c) regular pentagon
- (d) regular hexagon
- (e) right angled triangle

Answer: C

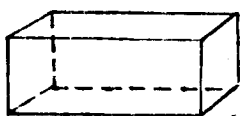
11. The shape of all the faces of a pyramid, excepting the base, is ?

Answer: triangular

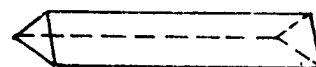
12. (1)



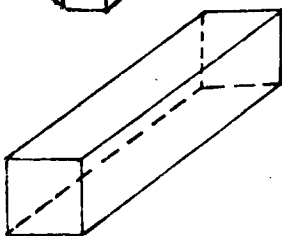
(2)



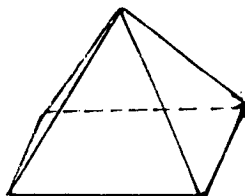
(3)



(4)



(5)



Of the figures above the following show prisms:

- (a) figure (5) only
- (b) figure (3) only
- (c) figures (1), (2), (3) and (4) only
- (d) figures (1), (2), (3), (4) and (5)
- (e) none of the above choices is correct.

Answer: C

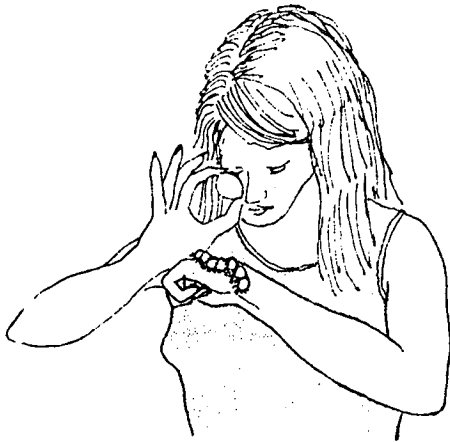


7. There are 2 sets of attribute blocks, set A and set B. Set A contains only medium sized thin objects. Set B contains only thick circles. Which of the following is the best description of the intersection, or overlap, of A and B?

- (a) empty set
- (b) medium sized circles
- (c) thick and thin medium objects
- (d) thick and thin circles
- (e) thick objects

Answer: A

- 
8. This girl is looking through a lens at a caterpillar.



She is holding the lens

- (a) in her left hand and up to her left eye
- (b) in her left hand and up to her right eye
- (c) in her right hand and up to her left eye
- (d) in her right hand and up to her right eye.

Answer: D

- 
9. How many unit cubes would you need to put together to make another cube of edge 3 units?

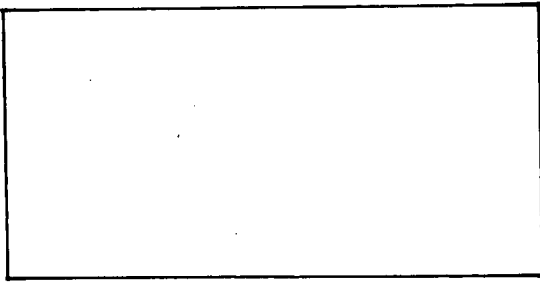
- (a) 3
- (b) 8
- (c) 9
- (d) 12
- (e) 27

Answer: E

13. In a sentence or two, describe what a tessellation is. As well, draw an example.

See Appendix F

14. How many axes of symmetry has a rectangle?



- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) an infinite number

Answer:

B

15. How many right angles are there on a cube (the edges of the cube forming the arms)?

- (a) 8
- (b) 12
- (c) 16
- (d) 18
- (e) 24

Answer:

E

16. In one week the hour hand of an electric clock goes round the face:

- (a) twice
- (b) 7 times
- (c) 12 times
- (d) 14 times
- (e) 168 times.

Answer:

D

17. Consider a rectangular block of wood.

How many surfaces or faces has it?

6

How many edges has it?

12

How many corners has it?

8

18. Which of the following is the best example of *vertical*?

- (a) a window sill
- (b) a tumble-down pioneer cottage
- (c) a telegraph pole
- (d) a map of Tasmania
- (e) a chalk box

Answer:

C

19. How many pairs of parallel edges are there in a regular pentagon?

Answer:

0

20. Which of the following is the best example of a cylinder?

- (a) a chair
- (b) a cardboard carton
- (c) a water pipe
- (d) a chalk box
- (e) the blackboard

Answer:

C

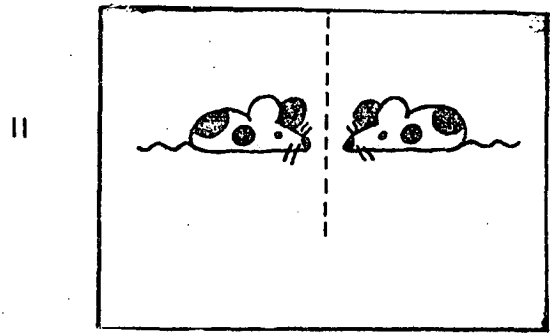
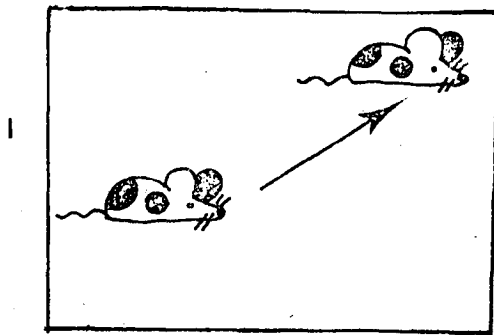
21. How many lines of rotational symmetry does a circle have?

- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) infinite

Answer:

E

22. The diagrams show two types of movement:



The type of movement in

I is:

- (a) rotation
- (b) reflection
- (c) translation
- (d) none of these.

C

The type of movement in

II is:

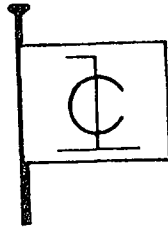
- (a) rotation
- (b) reflection
- (c) translation
- (d) none of these.

B

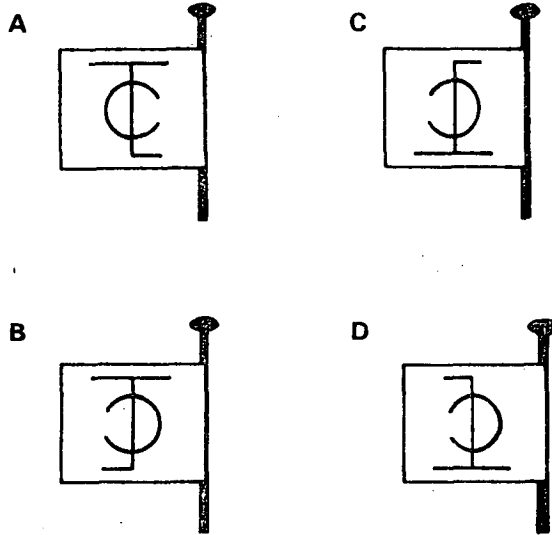
Answer:

I \_\_\_\_\_ II \_\_\_\_\_

23. This pattern has been woven right through the fabric of a flag which is blowing in a strong wind.



Which one of the following shows how the flag would look when the wind changes to the opposite direction?



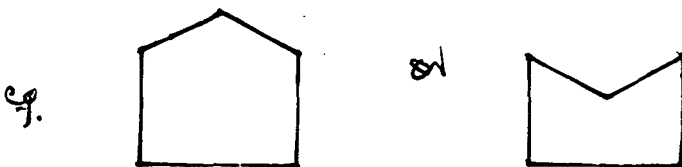
Answer:

C

24. In the space below construct a small grid and draw a triangle with area 3 square units.

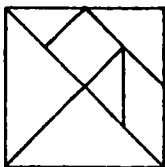
See Appendix F

25. Draw a 5-sided plane shape that will tessellate.



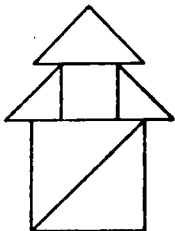
See Appendix

26. A tangram consists of seven geometric shapes formed by cutting up a square as shown.

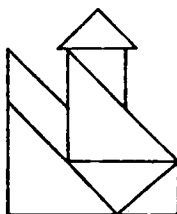


Which one of the following designs can be made by using all of the tangram pieces?

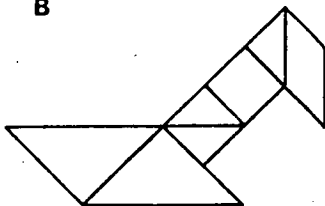
A



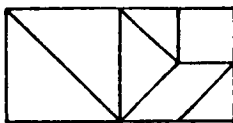
C



B

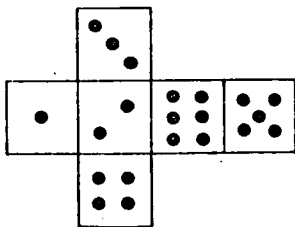


D



Answer: D

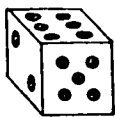
27. This pattern was drawn on cardboard, then cut and folded to make a hollow die.



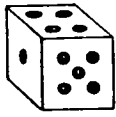
Which one of the following shows a view of the die so formed?



A



B



C



D

Answer: C

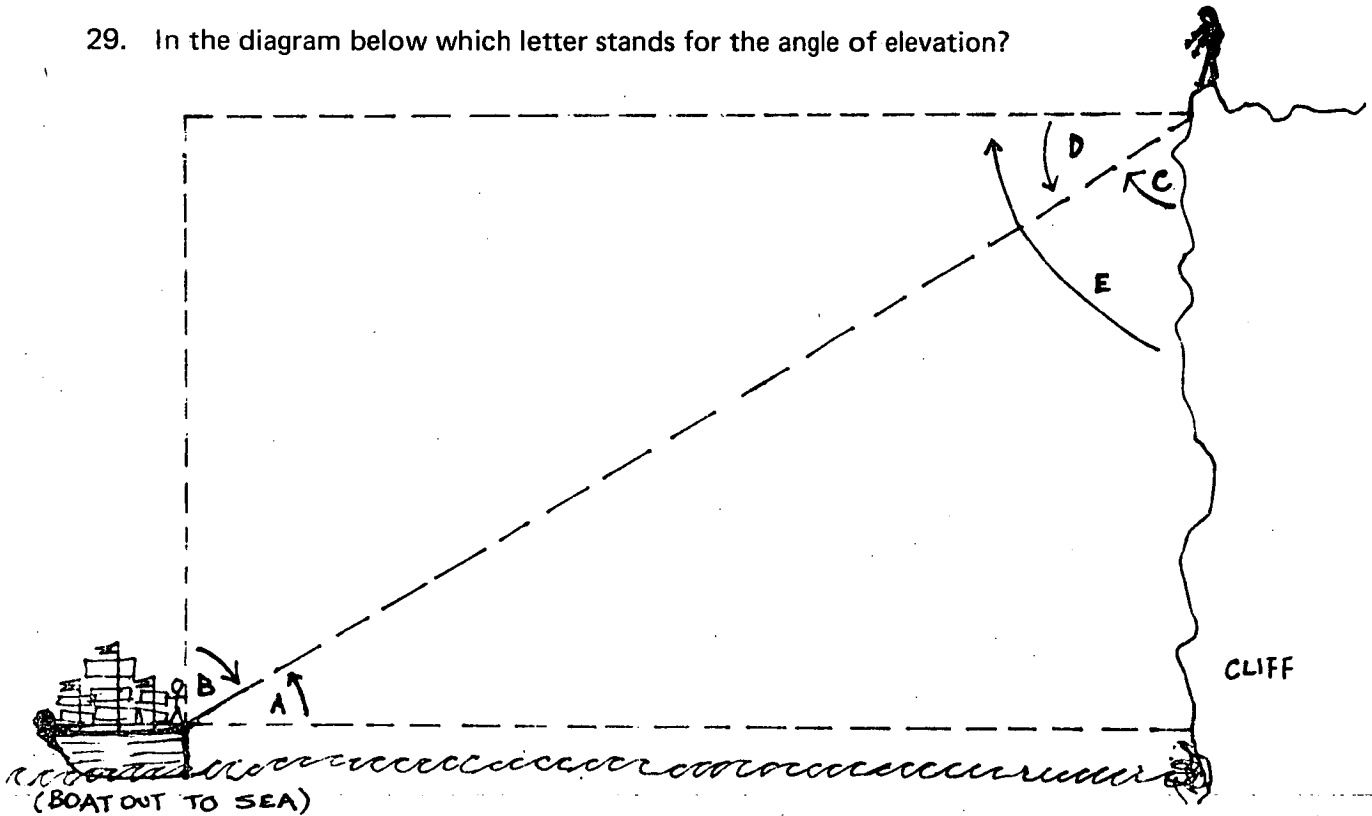
28. Margaret stands on a hilltop facing due north, then turns in a clockwise direction until she faces south-west. Through what angle has she turned?

- (a)  $135^\circ$  (c)  $225^\circ$   
(b)  $180^\circ$  (d)  $270^\circ$

Answer:

C

29. In the diagram below which letter stands for the angle of elevation?

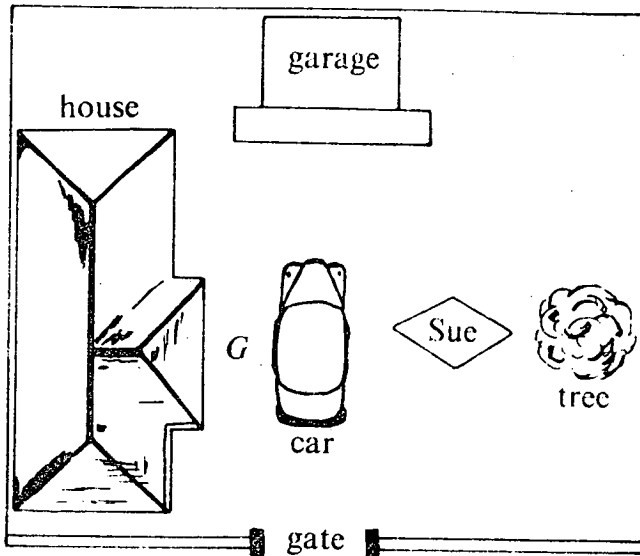


- (a) A  
(b) B  
(c) C  
(d) D  
(e) E

Answer:

A

30. Look at the picture below.

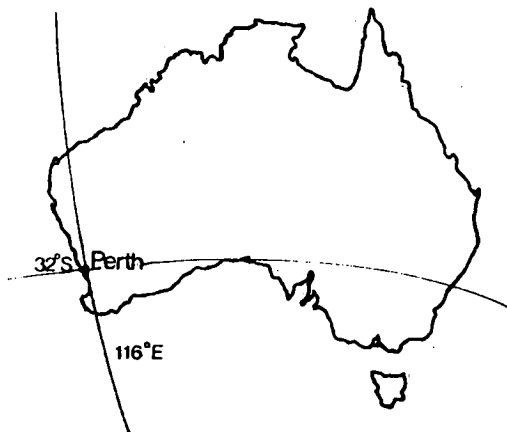


Sue walks around the car and stands at position G facing the gate. What is on Sue's left-hand side?

- (a) the house and car
- (b) the tree and car
- (c) the tree only
- (d) the garage

Answer: B

31. Perth has a latitude  $32^\circ$  South and a longitude  $116^\circ$  East. Bermuda is directly opposite Perth on the earth's spherical surface.



The latitude and longitude of Bermuda must be

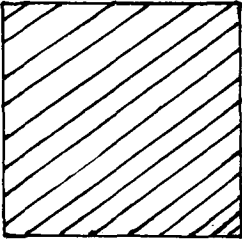
- (a)  $32^\circ$ S  $116^\circ$ W
- (b)  $32^\circ$ N  $116^\circ$ W
- (c)  $32^\circ$ S  $64^\circ$ W
- (d)  $32^\circ$ N  $64^\circ$ W.

Answer: D

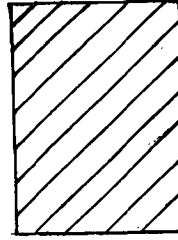


32. Which of the following could not be the shadow projection of a cube?

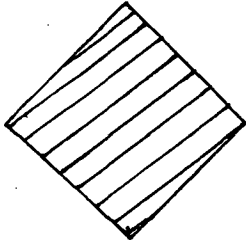
1)



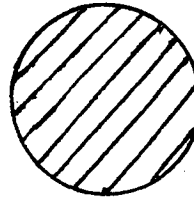
2)



3)



4)



(a) 1

(b) 2

(c) 3

(d) 4

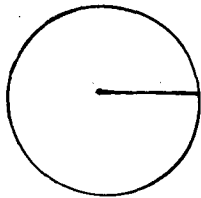
(e) more than one of the above.

Answer:

---

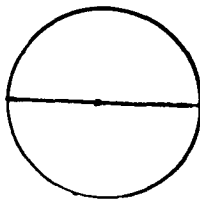
33. In circle A draw a radius.

A



In circle B draw a diameter.

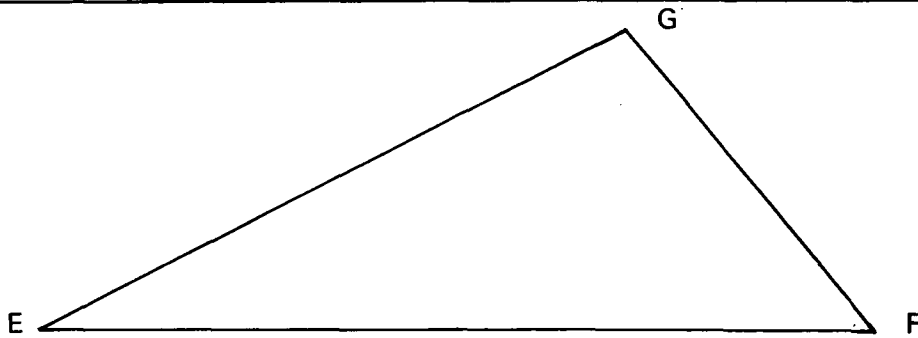
B



34. Give an example of a *parabola* or *parabolic motion* in nature.

See Appendix F

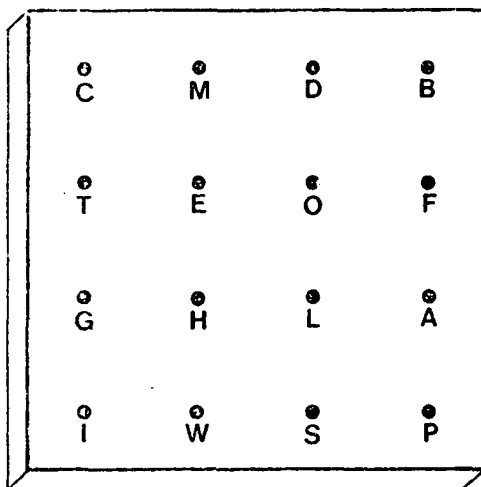
35.



If the measure of angle F is  $50^\circ$  and the measure of angle G is  $105^\circ$ , what is the measure of angle E?

Answer:  $25^\circ$

36. These letters represent pegs placed at equal intervals in rows and columns on the board. Triangles can be formed by stretching an elastic band around sets of three pegs.



Which one of the following triangles would be both rightangled and isosceles?

- (a) PIG                      (c) COW  
(b) BIT                      (d) WAM

Answer: C

**COMMENTS**

If there is any comment you wish to make on the test as a whole or on individual items feel free to do so.



Appendix F

Notes on the Marking of the Free-Response  
Items in SATT

There were nine free-response items in Form A of which three (qq. 4, 15 and 17) required only simple one or two word answers. This left six items where there was perhaps some judgement necessary on the part of the marker. In Form B there were also nine free-response items of which five (qq. 11, 17, 19, 33 and 35) required simple answers. This left four items requiring a little judgement. The explanations which follow formed the basis for the marking of these six and five items in Form A and Form B, respectively. The three common questions 13, 25 and 34 are dealt with first.

### The Common Questions

Question 13 It was difficult to decide how much latitude to allow for looseness of expression. The main criterion was 'repeated pattern' with one, possibly two, congruent shapes. Answers without a diagram were marked incorrect.

Question 25 There were two types of correct answers. The commonest was the 'house' pentagon, e.g.



Less common was the re-entrant or concave pentagon, e.g. All regular pentagons were marked incorrect.



Question 34 Any answer which implicitly or explicitly contained reference to gravity, e.g. "The path of a cricket ball", was marked correct. So too was any 'umbrella' shape, with or without axes. Answers which referred to waves, sun orbits or rainbows were marked incorrect.

### Form A

Questions 5 and 6 Considerable latitude was allowed in the marking of these questions. Virtually any criteria which formed two pairs of disjoint sets, one pair for each question, were accepted as correct. Among the commonest criteria were attributes based on shape of side and number of sides. When the sets description did not match the solid numbers used to indicate the contents of each set the answer was marked incorrect.

Question 10 Any repeated pattern using the triangle to tessellate, i.e. completely fill or cover the square was marked correct. A common incorrect response was to fill up the (large) square with just two large triangles.

### Form B

Question 24 The grid had to be reasonably rectilinear and the product of height and base length had to equal 6.

Appendix G

Source of Items used in SATT

I. Source of items used in SATT (Final Version)

Question number	SATT Form A	Changed or unchanged borrowed items	SATT Form B	Changed or unchanged borrowed items
1	original		original	
2	original		common question	
3	ACER Space II, q. 14	u	common question	u
4	original		NAEP q. RK11	c
5	original		ACER Teachers' College Test q. 51	u
6	original		original	
7	original		common question	
8	ACER Space I, q. 2	c	ACER Space I, q. 6	u
9	original		original	
10	original		original	
11	original		Bailey, q. 49	c
12	Banning q. 11	u	common question	u
13	original		common question	
14	ACER Space IV, q. 24	u	original	
15	original		original	
16	ACER A.M. 8, q. 3	u	ACER (test unknown)	u
17	original		common question	
18	original		original	
19	ACER Space II, q. 1	u	original	
20	original		original	
21	original		common question	
22	ACER Space I, q. 8	c	common question	c
23	ACER Space II, q. 4	u	ACER Space I,	u
24	ACER Space III, q. 21	u	original	



25	original		common question	
26	ACER Teachers' College Test q. 21	c	ACER Space II, q. 9	u
27	Dettrick Form III, q. 16	u	ACER Space II, q. 28	u
28	ACER (test unknown)	u	ACER Space III, q. 25	u
29	original		common question	
30	ACER AM 8, q. 9	u	ACER AM 8, q. 24	u
31	original		ACER Space IV, q. 25	u
32	original		original	
33	ACER AM 8, q. 25	u	original	
34	original		original	
35	original		NAEP, RK08	u
36	ACER Space III, q. 28	u	common question	u

## II. SOURCE of items used in SATT (Pilot Version)

There were only two questions different between the Pilot Version and the final version of SATT, question 23 in Form A and question 19 in Form B. Both of these were original questions.

Appendix H

The Monash Spatial Tests and Pilot Study Questionnaire

MONASH SPATIAL TEST A  
(Pilot study - inservice sample)

NAME: \_\_\_\_\_

SCHOOL: \_\_\_\_\_

SEX (tick the correct one): Female/Male

AGE (tick the correct one): 20-24/25-29/30-34/35-39/40-44/45-49/  
50-54/55-59/60-65

AT WHAT INSTITUTION DID YOU DO YOUR INITIAL TEACHER TRAINING?  
\_\_\_\_\_

FOR HOW MANY YEARS WAS YOUR INITIAL TEACHER TRAINING? \_\_\_\_\_

FOR HOW MANY YEARS HAVE YOU BEEN TEACHING? \_\_\_\_\_

WHAT GRADE DO YOU CURRENTLY TEACH? \_\_\_\_\_

(If you teach a composite class, just indicate the grade that has the most children.)

(If you do not have full-time responsibility for a class, write Librarian, Principal, Infant Mistress, etc.)

TO WHAT LEVEL DID YOU STUDY MATHEMATICS IN THE SECONDARY SCHOOL (tick the correct one): year 7 / 8 / 9 / 10 / 11 / 12

The answers to these questions and the spatial questions are strictly confidential. Upon completion please return to:

Mr Kevin Anderson.  
M. Ed. Student,  
Department of Educational Studies,  
Centre for Education,  
University of Tasmania,  
G.P.O. Box 252C,  
HOBART, Tas. 7001.

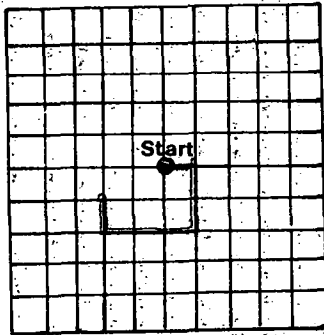
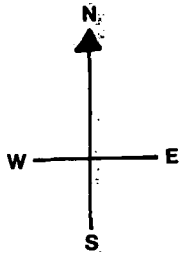
NAME: \_\_\_\_\_

MONASH SPATIAL TEST - FORM A

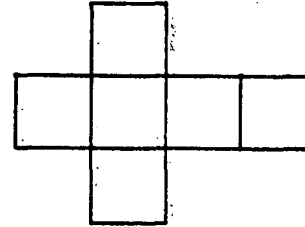
QUESTION 24

On the grid below draw your path from the following directions.

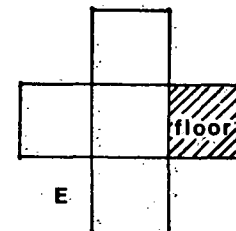
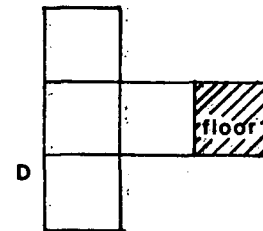
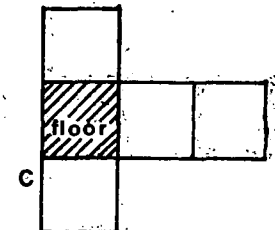
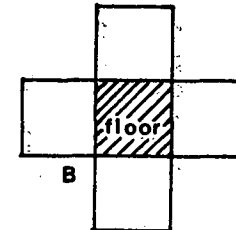
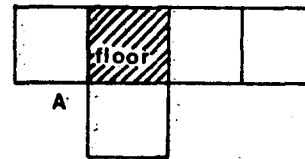
Directions: From the start face east and go 1 block, then turn right and go 2 blocks, then go west 3 blocks, then go north 1 block.



QUESTION 1



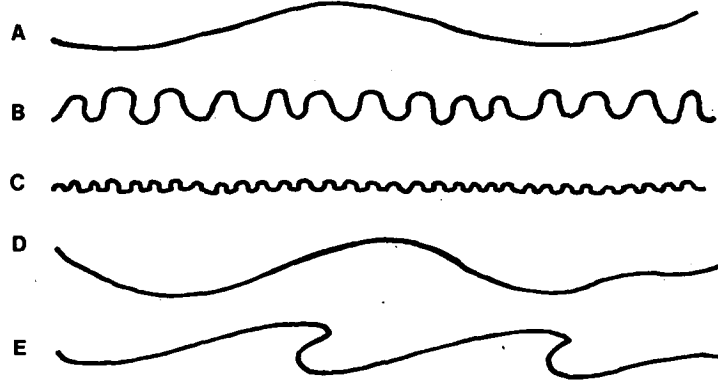
If you cut out the shape shown and folded it you could get a box with 4 walls, a roof and a floor. Suppose you wanted to get a box with 4 walls, a floor but NO ROOF. Which of A, B, C, D, E below would you cut out, GIVEN THAT THE FLOOR IS AS MARKED?



ANSWER: B

QUESTION 2

Which of the paths A, B, C, D, E is the longest?



ANSWER: B

QUESTION 23

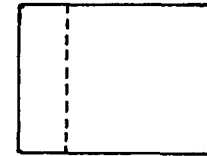


Figure 1

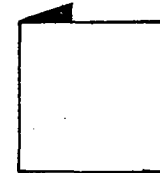


Figure 2

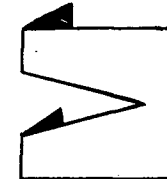
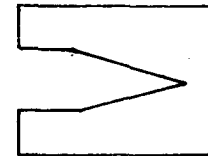


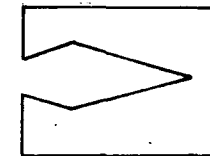
Figure 3

The rectangular piece of paper in Figure 1 is folded along the dotted line shown so that Figure 2 is obtained. The fold is then cut, as in Figure 3, and the paper is opened out again.

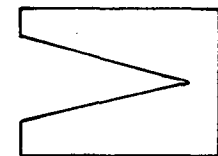
Which of A, B, C, D, E below shows what the remaining paper would look like?



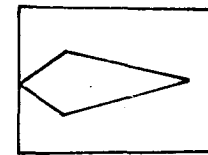
A



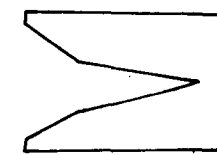
B



C



D



E

ANSWER: B

QUESTION 22

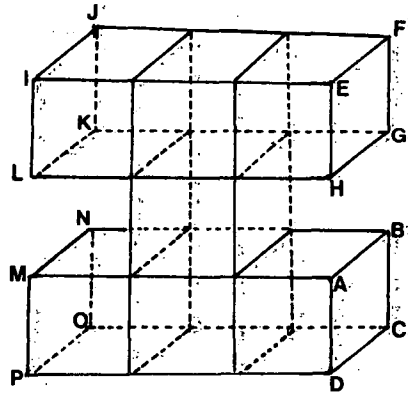


FIGURE 1

If the shape in Figure 1 was placed in the position shown in Figure 2, which would be the letters for the corners indicated by the arrows.

Write the correct letters in the circles.

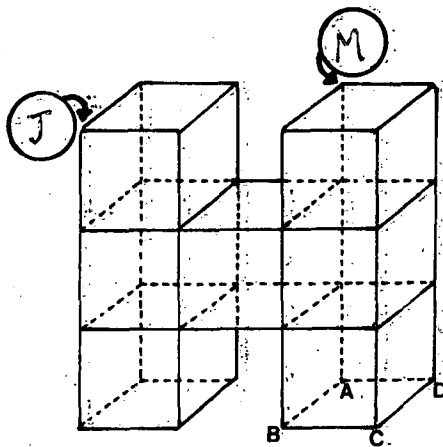


FIGURE 2

QUESTION 3

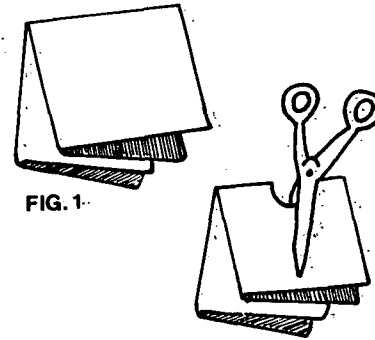


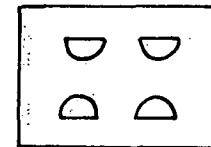
FIG. 1

FIG. 2

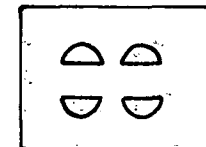
Suppose a rectangular piece of paper is folded twice so that it appears as in Figure 1.

Suppose you cut half a circle out of the folded paper, as shown in Figure 2.

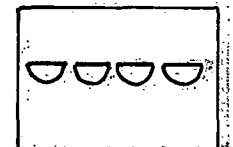
If you then opened out the piece of paper, which of A, B, C, D, E below would it look like?



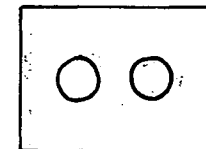
A



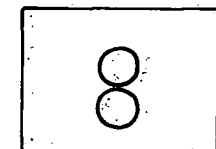
B



C



D



E

ANSWER: D

QUESTION 4

Which of A, B, C, D, E would complete the pattern if it were placed in the blank square in Figure 1?

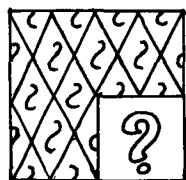


fig 1



a



b



c



d



e

ANSWER: \_\_\_\_\_

C

QUESTION 21

Which of the shapes A, B, C, D, E should replace the question mark in Figure 4?

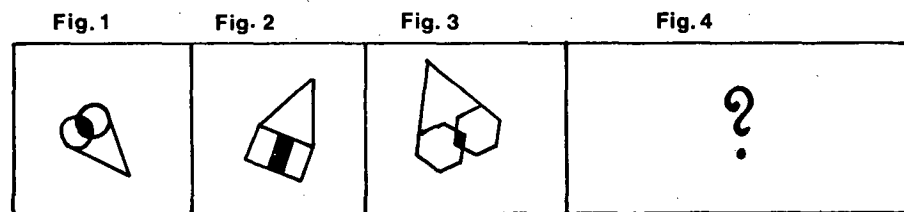


Fig. 1

Fig. 2

Fig. 3

Fig. 4



A



B



C



D



E

ANSWER: \_\_\_\_\_

C



QUESTION 20

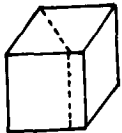
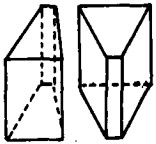


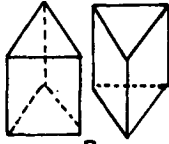
Fig 1

Suppose the cube shown in Figure 1 is cut into two sections along the dotted lines shown.

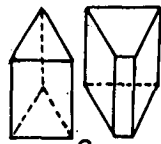
Which of A, B, C, D, E shows the two sections which would be obtained?



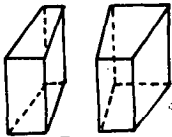
A



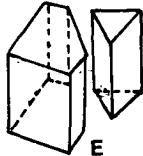
B



C



D



E

ANSWER:

C

QUESTION 5

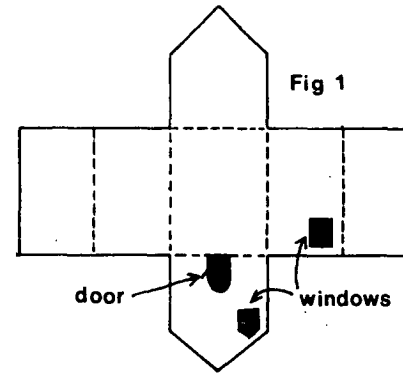
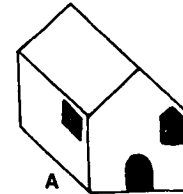


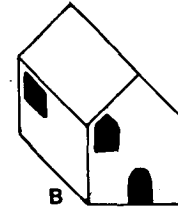
Fig 1

Figure 1 shows the plan of a house which has only one door and two windows.

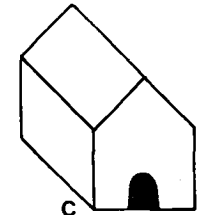
Which of A, B, C, D, E below could be the house?



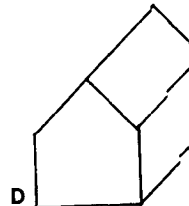
A



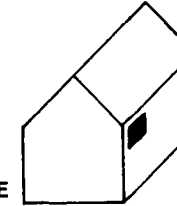
B



C



D



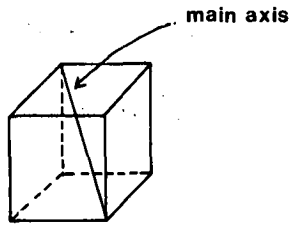
E

ANSWER:

D

QUESTION 6

A picture of a MAIN AXIS of a cube is shown.



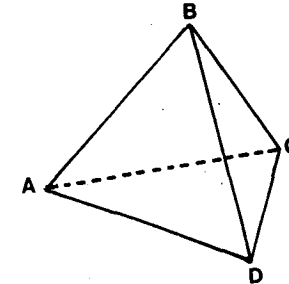
A main axis of a cube goes from a corner to the far opposite corner.

Altogether, how many different main axes does a cube have?

ANSWER: 4

QUESTION 19

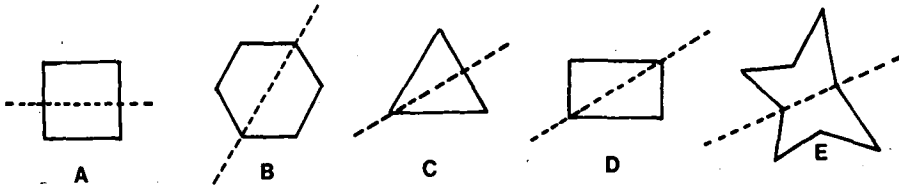
A picture of a regular tetrahedron ABCD is shown; all of its faces are triangular. How many faces does a regular tetrahedron have?



ANSWER: 4

QUESTION 18

Which of A, B, C, D, E cannot be folded along the dotted line so that one half fits exactly over the other half?



ANSWER: D

QUESTION 7

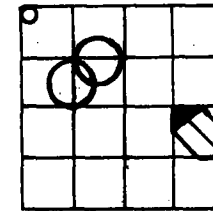


FIG. 1

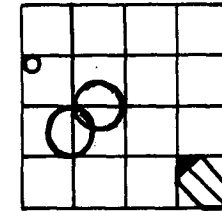


FIG. 2

Have a look at Figures 1 and 2, and think of the rule by which Figure 2 is obtained from Figure 1.

Now complete Figure 3 below so that Figure 4 is obtained from Figure 3 by the same rule as Figure 2 was obtained from Figure 1.

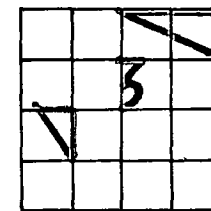


FIG. 3

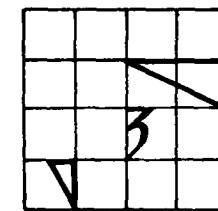
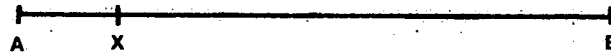


FIG. 4

QUESTION 8

Suppose AB is a piece of wire which is folded into a closed shape with straight sides so that each side is of the same length, and AX is one of the sides. How many sides would the closed shape have?



ANSWER: 6

QUESTION 17

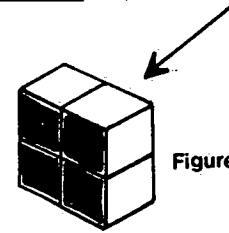
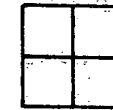


Figure 1

Suppose you looked at the shape in Figure 1 so that your eyes were looking along the arrow.



The shape you would see would look like Figure 2.

Figure 2

Suppose this time you looked at the shape in Figure A so that your eyes were looking along the arrow. In the answer square provided draw the shape that Figure A would look like to you.

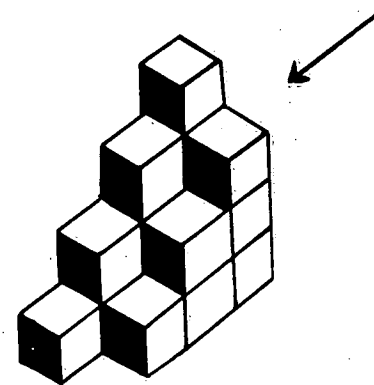
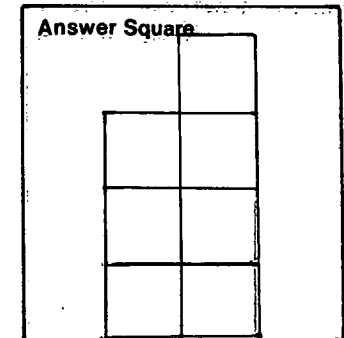
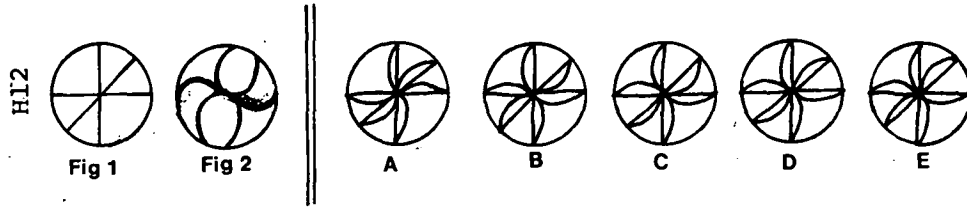


Figure A



QUESTION 16

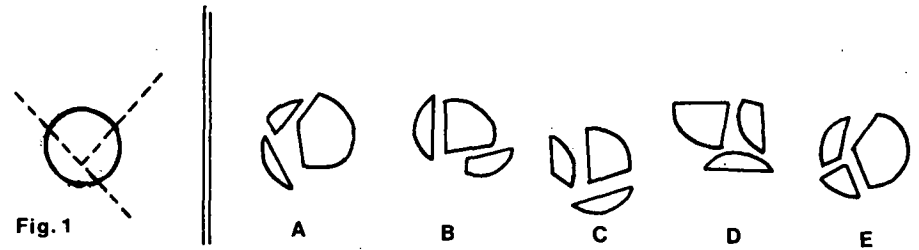
If Figure 1 were placed on Figure 2, which of A, B, C, D, E would be obtained?



ANSWER: B

QUESTION 9

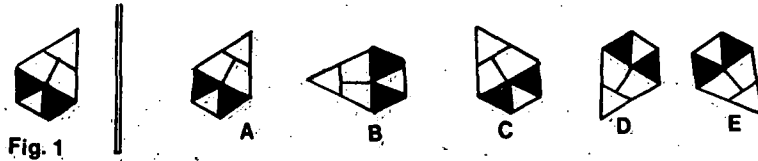
Suppose the circle in Figure 1 is cut into 3 sections along the dotted lines shown. Which of A, B, C, D, E shows the 3 sections which would be obtained?



ANSWER: B

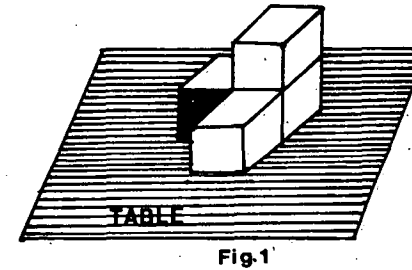
QUESTION 10

Suppose you saw the picture in Figure 1 on a window, and you then looked at the picture from the other side of the window. Which of Figures A, B, C, D, E would it now look like?



ANSWER: C

QUESTION 15



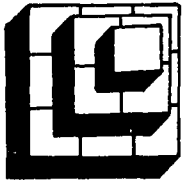
Four cubes were joined together and then stuck to a table, as shown in Figure 1, so that the shape could not be lifted from the table. The parts of the shape not stuck to the table were then painted.

If one face of a cube is called a square section, how many square sections were painted, altogether?

ANSWER: 15

QUESTION 14

How many unit cubes when placed together, would make this stack?



ANSWER: \_\_\_\_\_

14

QUESTION 11

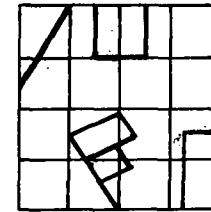


FIG. 1

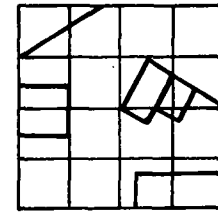


FIG. 2

Have a look at Figures 1 and 2, and think of the rule by which Figure 2 is obtained from Figure 1.

Now complete Figure 4 below so that Figure 4 is obtained from Figure 3 by the same rule as Figure 2 was obtained from Figure 1.

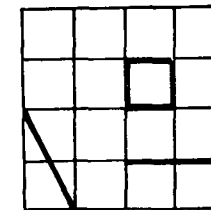


FIG. 3

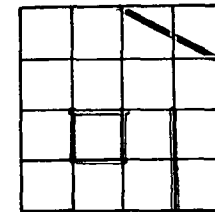
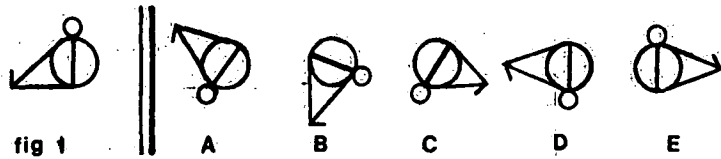


FIG. 4

QUESTION 12

Look at Figures A, B, C, D, E. Which of these can be rotated on this page to match Figure 1 exactly?



ANSWER: C

QUESTION 13

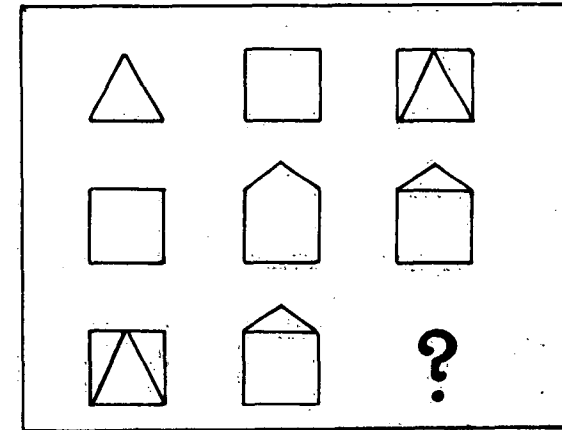
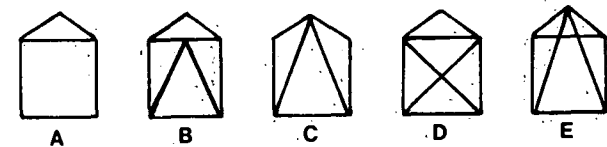


FIG.1

Which of A, B, C, D, E below should replace the question mark in Figure 1?



ANSWER: B



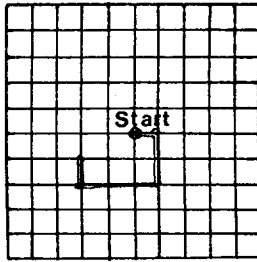
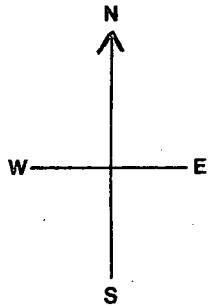
MONASH SPATIAL TEST - FORM B

NAME: \_\_\_\_\_

QUESTION 24

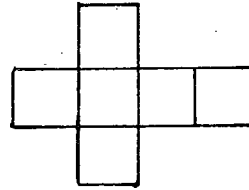
On the grid below draw your path from the following directions:

Directions: From the start face east and go 1 block, then turn right and go 2 blocks, then go west 3 blocks, then go north 1 block.

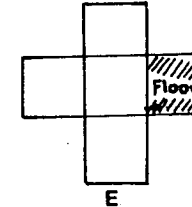
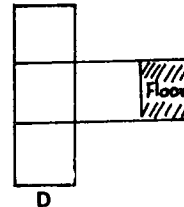
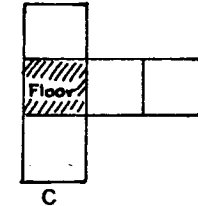
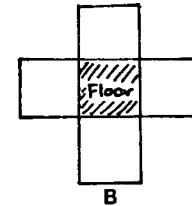
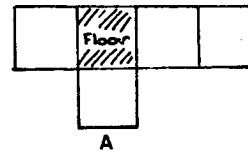


HL7

QUESTION 1



If you cut out the shape shown and folded it you could get a box with 4 walls, a roof, and a floor. Suppose you wanted to get a box with 4 walls, a floor, but NO ROOF. Which of A, B, C, D, E below would you cut out, GIVEN THAT THE FLOOR IS AS MARKED?



ANSWER: B

QUESTION 2

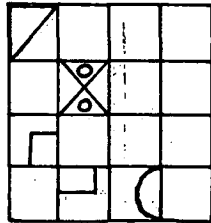


fig 1

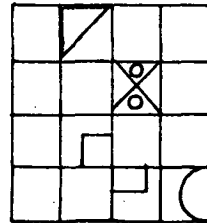


fig 2

Have a look at Figures 1 and 2, and think of the rule by which Figure 2 is obtained from Figure 1.

Now complete Figure 4 below so that Figure 4 is obtained from Figure 3 by the same rule as Figure 2 was obtained from Figure 1.

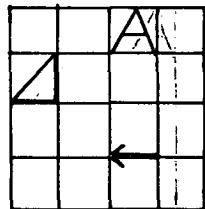


fig 3

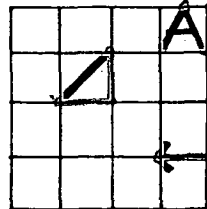


fig 4

QUESTION 23

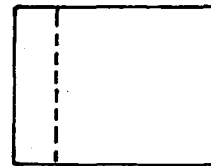


fig.1

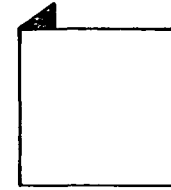


fig. 2

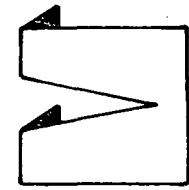
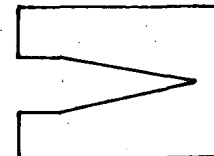


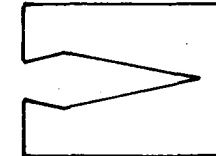
fig.3

The rectangular piece of paper in Figure 1 is folded along the dotted line shown so that Figure 2 is obtained. The fold is then cut, as in Figure 3, and the paper is opened out again.

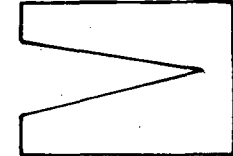
Which of A, B, C, D, E below shows what the remaining paper would look like?



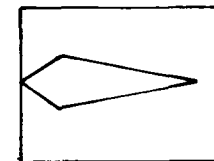
A



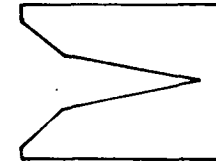
B



C



D



E

ANSWER: B

QUESTION 22

Which of the shapes A, B, C, D, E belongs with Figures 1, 2, 3?

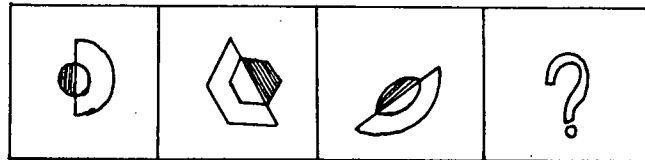


fig 1

fig 2

fig 3



A



B



C



D



E

ANSWER:

D

QUESTION 3

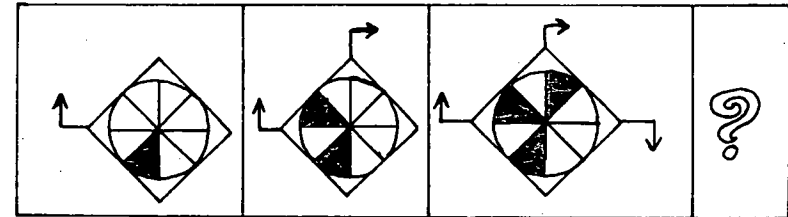


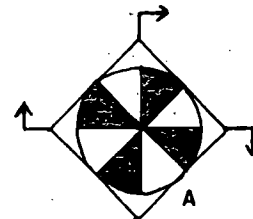
fig 1

fig 2

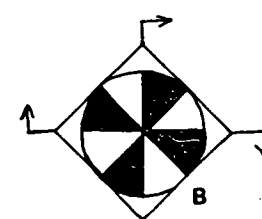
fig 3

fig 4

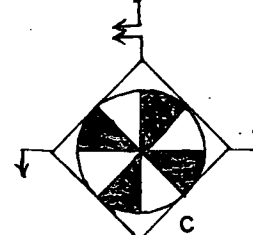
Which of A, B, C, D, E below should replace the question mark in Figure 4?



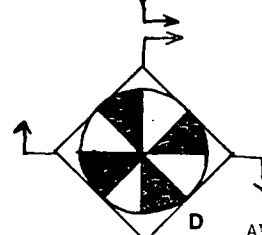
A



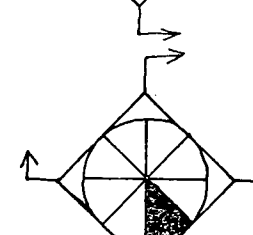
B



C



D



E

ANSWER:

A

QUESTION 4

Which of A, B, C, D, E would complete the pattern if it were placed in the blank square in Figure 1?

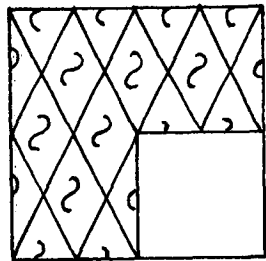
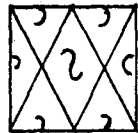
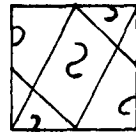


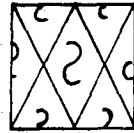
FIG. 1



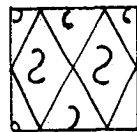
A



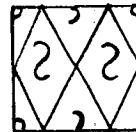
B



C



D



E

ANSWER: \_\_\_\_\_

C

QUESTION 21

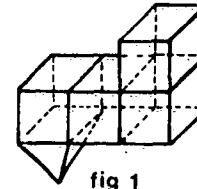
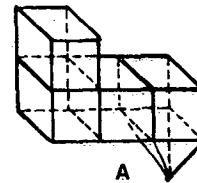
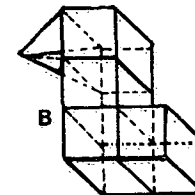


fig 1

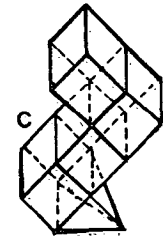
Look at Figures A, B, C, D, E.  
Which of these figures does NOT  
have exactly the same shape as  
Figure 1?



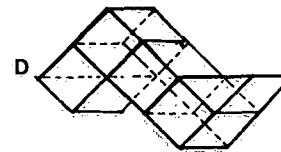
A



B



C



D



E

ANSWER: \_\_\_\_\_

D

QUESTION 20

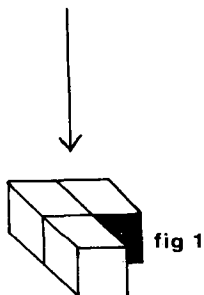


fig 1

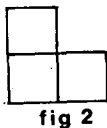


fig 2

Suppose you looked at the shape in Figure 1 so that your eyes were looking along the arrow.

The shape you would see would look like Figure 2.

Suppose this time you looked at the shape in Figure A so that your eyes were looking along the arrow. In the answer square provided draw the shape that Figure A would look like to you.

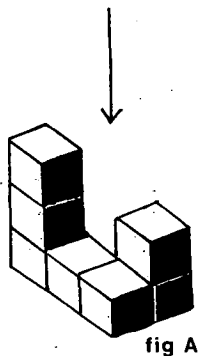
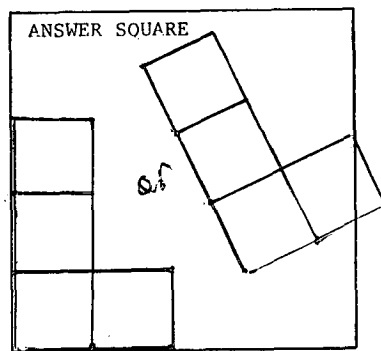


fig A



QUESTION 5

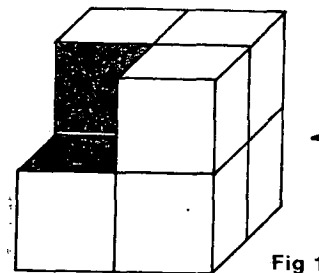


Fig 1

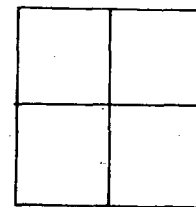


Fig 2

Suppose you looked at the shape in Figure 1 so that your eyes were looking along the arrow.

The shape you would see would look like Figure 2.

Suppose this time you looked at the shape in Figure A so that your eyes were looking along the arrow. In the answer square provided draw the shape that Figure A would look like to you.

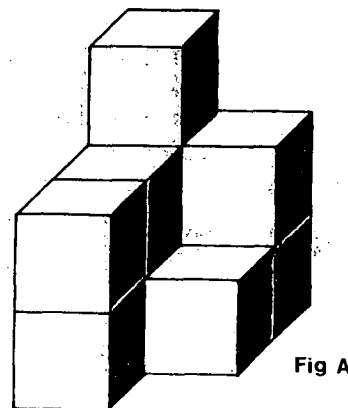
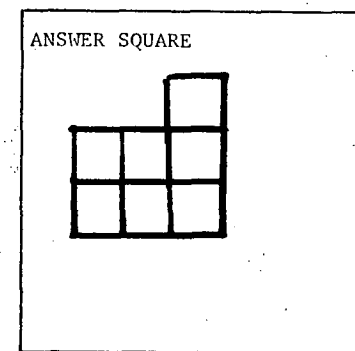
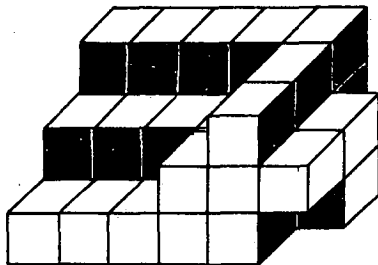


Fig A



QUESTION 6

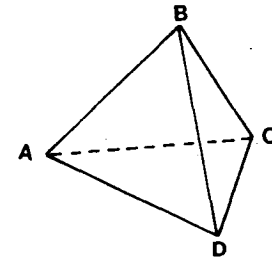
How many blocks are there in this stack?



ANSWER: 37

QUESTION 19

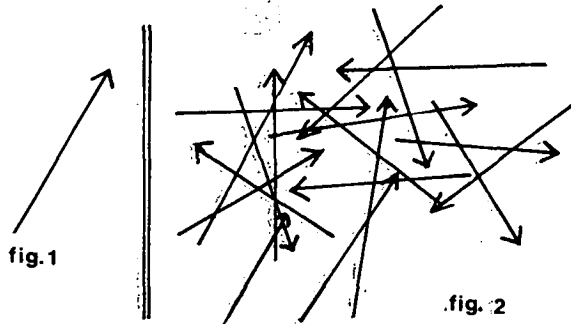
A picture of a regular tetrahedron ABCD is shown; all of its faces are triangular. How many faces does a regular tetrahedron have?



ANSWER: 4

QUESTION 18

Look at the arrow in Figure 1. How many of the arrows in Figure 2 are pointing in the same direction as this arrow?



ANSWER: 3

QUESTION 7

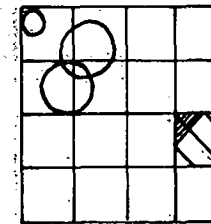


Fig 1

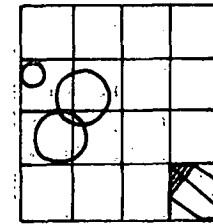


Fig 2

Have a look at Figures 1 and 2, and think of the rule by which Figure 2 is obtained from Figure 1.

Now complete Figure 3 below so that Figure 4 is obtained from Figure 3 by the same rule as Figure 2 was obtained from Figure 1.

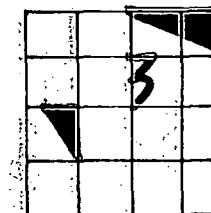


Fig.3

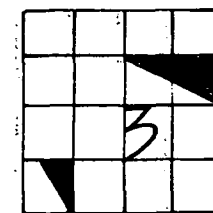
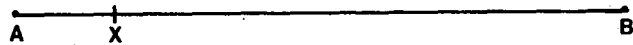


Fig 4



QUESTION 8

Suppose AB is a piece of wire which is folded into a closed shape with straight sides so that each side is of the same length, and AX is one of the sides. How many sides would the closed shape have?



ANSWER: 6

QUESTION 17

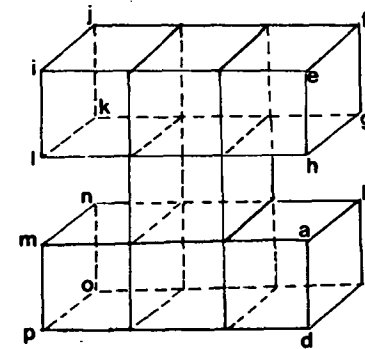


fig 1

If the shape in Figure 1 was placed in the position shown in Figure 2, which would be the letters for the corners indicated by the arrows.

Write the correct letters in the circles.

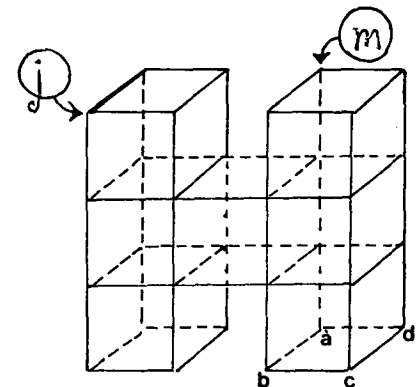


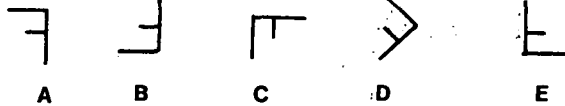
fig 2

QUESTION 16



Fig 1

Which of the signs A, B, C, D, E can be printed with the stamp shown in Figure 1?



ANSWER:

B

QUESTION 9

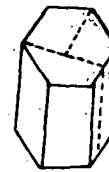
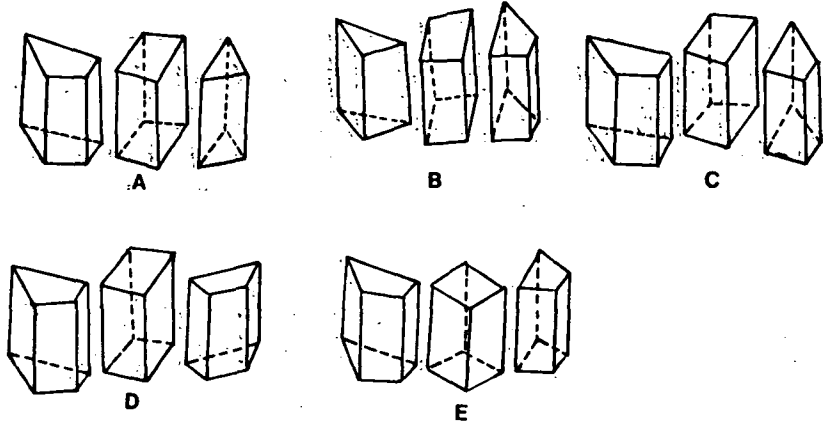


Fig1

Suppose the shape shown in Figure 1 is cut into 3 sections along the dotted lines shown.

Which of A, B, C, D, E, shows the 3 sections which would be obtained?

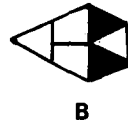
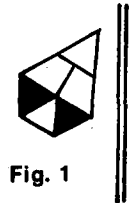


ANSWER:

C

QUESTION 10

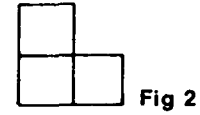
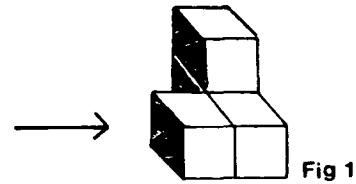
Suppose you saw the picture in Figure 1 on a window, and you then looked at the picture from the other side. Which of Figures A, B, C, D, E would it now look like?



ANSWER: \_\_\_\_\_

C

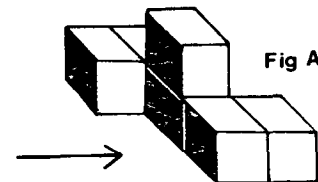
QUESTION 15



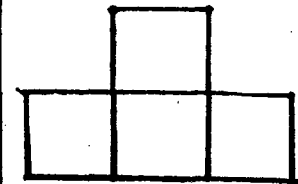
Suppose you looked at the shape in Figure 1 so that your eyes were looking along the arrow.

The shape you would see would look like Figure 2.

Suppose this time you looked at the shape in Figure A so that your eyes were looking along the arrow. In the answer square provided draw the shape that Figure A would look like to you.

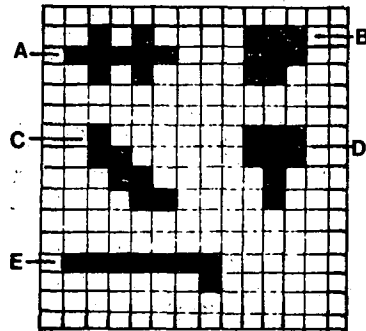


ANSWER SQUARE



QUESTION 14

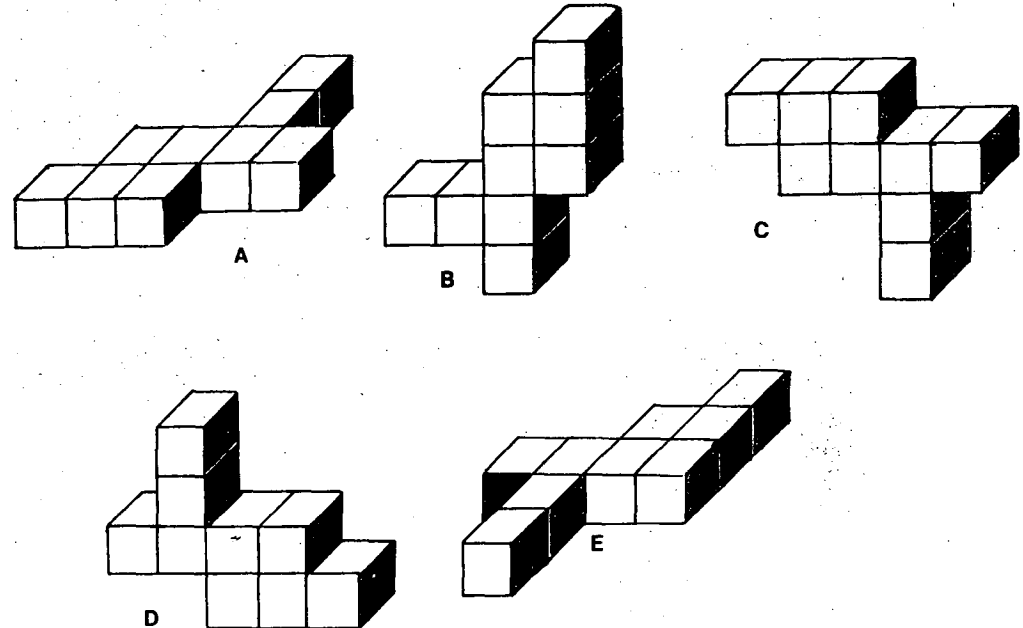
Look at the shaded sections marked A, B, C, D, E. Which section has the smallest area?



ANSWER: C

QUESTION 11

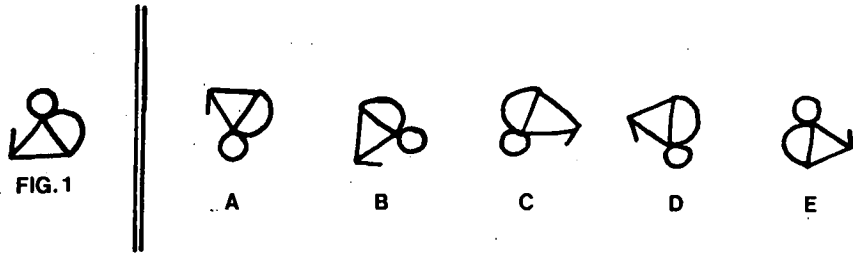
Each of the following five figures is made out of wooden blocks which are exactly the same size. If you are allowed to move each figure about, rotate it, and turn it over, which figure could NOT exactly cover the other four?



ANSWER: E

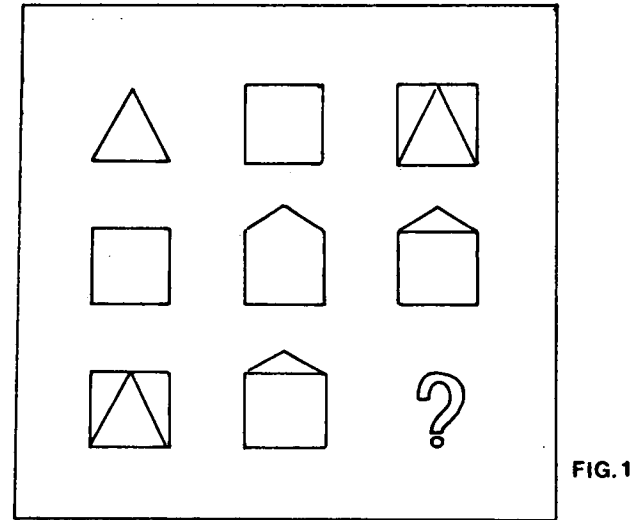
QUESTION 12

Look at Figures A, B, C, D, E. Which of these can be rotated on this page to match Figure 1 exactly?

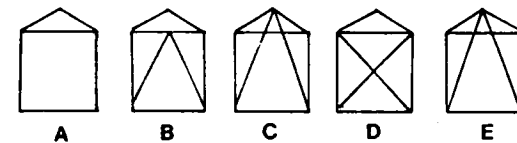


ANSWER: C

QUESTION 13



Which of A, B, C, D, E below should replace the question mark in Figure 1?



ANSWER: B

Appendix I

Instruction Sheets for Supervisors - SATT and MST

INSTRUCTION SHEET FOR SUPERVISORSSPATIAL AWARENESS TEACHING TEST - Form A and Form B

The person supervising the test should read the following statement immediately after each subject has been handed the test booklet.

- "(i) The purpose of this test is to discover your abilities with material in the Spatial Awareness strand of the Primary Mathematics Guidelines. All of your answers and comments are strictly confidential.
- (ii) Take your pen and fill in the questionnaire on page 1. ... Note the box at the bottom of page 1 which you can tick if you would like to know your result. As well note the inside of the last page of the booklet, headed Comments, where there is space for you to comment on the test.
- (iii) Altogether there are 36 questions in the test, and you should try to answer each question, even if you are not sure of some of them.
- (iv) There is no time limit on the test. Work steadily, and do not spend too much time on any one question. Put your answers in the spaces provided. If at any stage you have any questions raise your hand, although no help with definitions can be given. Rough working can be done on the side or back of your test booklet. Now turn to the start of the test on page 3. There are questions on both sides of the pages. You can now start the test."

\* \* \* \* \*

INSTRUCTION SHEET FOR SUPERVISORS

MONASH SPATIAL TEST - FORM A and FORM B

PRE-SERVICE SAMPLE

The person supervising the test should read the following statement immediately after each student has been handed the test booklet.

- "(i) The purpose of this test is to discover your strengths and weaknesses in spatial thinking.
- (ii) Take your pen and write down your name on the test booklet.
- (iii) Altogether there are 24 questions, and you should try to answer each question, even if you are not sure of some of them.
- (iv) You will have exactly 40 minutes to do the test. Work steadily, and do not spend too much time on any one question. Put your answers in the spaces provided. If at any stage you have any questions raise your hand. Rough working can be done on the side of your test paper. Now turn over the front page. There are questions on both sides of the pages. You can now start the test."

No help should be given to a student by the supervisor. For example, the supervisor should agree to a request to go to the toilet, but the supervisor should not agree to a request to "please read me out question 7".

The supervisor should indicate "time used", by marking off 10 minute intervals on a blackboard, or other similar board.

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Appendix J

Letters to Teachers and the article from  
The Tasmanian Teacher



# The University of Tasmania

CENTRE FOR EDUCATION  
Department of Educational Studies

23rd June, 1982

Box 252C, G P O., Hobart,  
Tasmania, Australia 7001  
Telephone: (002) 202101  
Cables 'Tasuni'  
Telex: 58150 UNTAS

## The Spatial Abilities and Spatial Awareness Project

We are currently engaged in a research study of the spatial abilities and the Spatial Awareness knowledge of Tasmanian pre-service and inservice teachers. This study is concerned both with teachers' abilities to form and retain mental images, and teachers' knowledge of Spatial Awareness concepts as outlined in the (Tasmanian) Primary Mathematics Guidelines.

The study is important, we feel, because so little is known of teachers' strengths and weaknesses in these areas, and the results could provide useful information for teacher training and inservice education, especially in mathematics.

The project started at the beginning of 1981. Much time has been spent selecting, devising and trialling appropriate tests. One way or another we have already tested the entire population of 1981 1st year and 1982 4th year pre-service teachers in Tasmania. As well, tests have been trialled with the staffs of a number of schools.

The last phase of the project has now begun. This involves the testing of inservice Infant and Primary teachers. You are one of a large, randomly-chosen sample of Tasmanian Education Department teachers selected to take part, hopefully, in this last phase. Next week you will receive 2 test booklets by mail. We would be most grateful if you would complete them, preferably within a week, and return them in the stamped addressed envelope provided.

The test booklets do not require your name and in any case all data will be treated in the strictest confidence. Analysis of the results will be by group comparisons and the only information to be published will be in summary form.

The project has the approval of the Director-General of Education, and the support of the Tasmanian Teachers' Federation.

If you have any questions about the project you can write or telephone us on (002) 202101 x2570 or x2577. Reverse the charges if you wish.

Yours sincerely,

Dr Malcolm Eley,  
Mr Kevin Anderson,  
The Spatial Abilities and Spatial Awareness Project

# The University of Tasmania

DEPARTMENT OF EDUCATION  
Department of Educational Studies

30th June, 1982

Box 252C, G.P.O., Hobart,  
Tasmania, Australia 7001

Telephone: (002) 202101

Cables 'Tasuni'

Telex: 58150 UNTAS

## The Spatial Abilities and Spatial Awareness Project

Recently we wrote to you about our research study, and asked for your co-operation in completing 2 test booklets which we would be sending to you. As we pointed out then, very little seems known of teachers' abilities in the important spatial awareness area of the curriculum.

We now enclose a copy of the 2 test booklets - the Monash Spatial Test and the Spatial Awareness Teaching Test - and we ask if you could complete each, and return them to us, preferably within the next week. So that conditions between all teachers and between inservice teachers and pre-service teachers can be as similar as possible we have enclosed in each test a copy of the supervisor's instructions to be read before doing the tests. To make valid comparisons between groups we ask that:

- (i) the 2 tests be done together in the I sitting,
- (ii) the Monash Spatial Test be done first,
- (iii) no concrete objects be used,
- (iv) no one else be consulted, and
- (v) no references or texts or the Primary Mathematics Guidelines be referred to.

Pencil and paper figures and drawings are permitted. You may wish to use the back cover of the tests, or the space at the side of the question. We estimate that the Monash Spatial Test will take about 30 minutes and the Spatial Awareness Teaching Test 30 to 50 minutes, i.e. about 1 hour to 1 hour 20 minutes altogether.

Would you please ensure that you also complete the questionnaire on page 2 of the Spatial Awareness Teaching Test. The information from this questionnaire will be used in looking for any relationships between test performance and particular group characteristics. For example, consider the group of teachers trained before the introduction of the Guidelines in 1978. How does their knowledge of new material in the Guidelines compare with their knowledge of other, older material?

There is a box at the bottom of page 2 of the Spatial Awareness Teaching Test for you to tick if you would like to know of your result. As well, note that on the inside back cover there is a page headed Comments. Feel free to make any comment concerning the test or individual items.

Please turn over.

The test booklets carry an identification number. This is to preserve your anonymity during data processing, but at the same time to allow us to notify you of your results if you so wish. As well, it will be used to ensure that you are not sent a reminder asking you to complete and return the tests, if indeed you have already done so.

As you will realise, the success of this research depends on the participation of those to whom these tests are sent. If you have any questions please do not hesitate to write or telephone us on (002) 202101 x2570 or x2577. Reverse the charges if you wish.

As indicated in our previous letter, this research has the approval of the Director-General of Education. Further, as you will see from the copy of the letter we have enclosed, the project also has the support of the Tasmanian Teachers' Federation.

A stamped addressed return envelope is enclosed for your convenience.

Thank you for your participation.

Yours sincerely,

Dr Malcolm Eley,  
Mr Kevin Anderson,  
The Spatial Abilities and Spatial Awareness Project

Enc.



# The University of Tasmania

CENTRE FOR EDUCATION

Department of Educational Studies

7th July, 1982

Box 252C, G.P.O., Hobart  
Tasmania, Australia 7000

Telephone: (002) 202101

Cables 'Tasuni'

Telex: 58150 UNTAS

## The Spatial Abilities and Spatial Awareness Project

You will recall our 2 letters to you recently seeking your co-operation in our research. Accompanying the last letter was a copy of each of the Monash Spatial Test and the Spatial Awareness Teaching Test, and a stamped addressed envelope in which to return both.

At the time of writing, your completed tests have not yet been received, although of course they could still be in the mail. If you have not already completed the tests and posted them we would be most grateful if you could do so at your earliest convenience. While we are aware of the many professional demands on your time, your completed tests, together with any comments you might wish to make, will make a valuable contribution to our research. This research in turn, we hope, will have the potential to make a valuable contribution to mathematics education in Tasmania.

We would like to assure you, again, that all your answers and comments will be treated in the strictest confidence. If you would like more information about the project please telephone us on (002) 202101 x2570 or x2577. Reverse the charges if you wish.

We look forward to receiving your tests and comments. They are important to our research.

Yours sincerely,

Dr Malcolm Eley,  
Mr Kevin Anderson,  
The Spatial Abilities and Spatial Awareness Project



# The University of Tasmania

CENTRE FOR EDUCATION  
Department of Educational Studies

14th July, 1982

Box 252C, G.P.O., Hobart,  
Tasmania, Australia 7001

Telephone: (002) 202101

Cables 'Tasuni'

Telex: 58150 UNTAS

## The Spatial Abilities and Spatial Awareness Project

A little while ago we wrote telling you of our research into the spatial abilities and Spatial Awareness competence of Tasmanian teachers. As well we told you that you were one of a large randomly-chosen group of Infant and Primary teachers selected to take part in our survey. The anonymity and confidentiality of your answers and comments were indicated and you were invited to contact us if you needed more information.

A week later we sent you a copy of the Monash Spatial Test and the Spatial Awareness Teaching Test. A stamped addressed envelope was also enclosed for their return. When they were not received within the next week we sent you a reminder. In this reminder we stated the importance to our research of receiving your completed tests. We mentioned again the anonymity and confidentiality of your answers and comments and again invited you to contact us if you needed more information.

You will undoubtedly appreciate the considerable time and cost that has gone into devising, trialling, and printing these tests. There has also been considerable time and cost in compiling the list of Tasmania-wide Infant and Primary teachers and in distributing the letters and tests to them. However our effort to ensure the success of the project needs, in addition, the co-operation of each of our sample of teachers by completing the tests. A 100% response rate - and this means receiving all tests - will mean that answers and comments from the sample can be taken as being truly representative of Infant and Primary teachers throughout the state.

Unfortunately we have not received your tests. While the response rate to date has been good there are still a number of teachers who have not completed them. Yours are needed. If you would like more information please telephone us on (002) 202101 x2570 or x2577. Reverse the charges if you wish.

We look forward to receiving your tests and comments. Your efforts in completing the tests will be appreciated and it will make a valuable contribution to our research.

Yours sincerely,

Dr Malcolm Eley,  
Mr Kevin Anderson,  
The Spatial Abilities and Spatial Awareness Project

# The Tasmanian Teachers Federation

Address all communication  
to the General Secretary.



32 Patrick Street,  
HOBART, 7000.  
Telephone: 34 9500

20 August, 1981.

Mr. K Anderson.  
M. Ed. Student,  
Department of Educational Studies,  
Centre for Education,  
University of Tasmania,  
G.P.O. Box 252C,  
HOBART, TAS., 7001.

Dear Kevin,

SPATIAL ABILITIES AND SPATIAL AWARENESS PROJECT

The Federation is extremely interested in getting more objective information about the Teaching Service and about education generally in this State and we have welcomed initiatives being taken by the University recently, and by University students in particular.

I would like particularly to support the project being undertaken by yourself on the Spatial Abilities and the Spatial Awareness Teaching Competence of Pre-service and Inservice Teachers. I am convinced that this study is of great importance to teachers in this State and that it could well have implications for improving the pre and in-service education of teachers.

I understand that you will be approaching schools and teachers for support and I am sure that the members of the Federation will be very willing to assist you in this project you in this project.

With best wishes,

Yours sincerely,

A handwritten signature in dark ink, appearing to read "A. R. Butler". The signature is fluid and cursive.

(A. R. Butler)  
PRESIDENT.

## THE TASMANIAN TEACHER

June 1982, p.12.

## New study on teachers and maths education

A study which looks at the Spatial Awareness skills of Tasmanian Infant and Primary teachers is currently being undertaken by two university researchers. They are Dr Malcolm Eley, Senior Lecturer in Educational Psychology, and Mr Kevin Anderson, a research M. Ed. student, both from the Department of Educational Studies within the University Centre for Education.

"It seems that there is little data on teachers' strengths and weaknesses in this important area of space and spatial skills. These skills are not only important for mathematics but also for the social sciences and mapping, reading and symbol recognition, physical education, etc," said Mr Anderson.

"Already we have tested many of

the 4th year Infant and Primary trainee-teachers at the TCAE, Newnham, and at the Department of Teacher Education at the UCE. Our preliminary assessment of the results suggests that many of the spatial abilities assumed in teachers may, in fact, be underdeveloped or even absent.

"The next phase of our project involves testing classroom teachers. We have compiled a 1 in 10 random listing of teachers to whom we will be writing during weeks 2 and 3 of Term II. We hope that the information gained from this study will have the potential to make a significant contribution to teacher-training and in-service education here in Tasmania in the years to come.

"The study has the approval of the Director-General of Education, Mr B. G. Mitchell, and the support of the TTF," Mr Anderson said.



Appendix K

Teacher and Student Teacher Comment on SATT

The symbol associated with each comment consists of 2 parts, letters and numbers. The first letter, T or S, corresponds to teachers or student teachers. The second letter for teachers, I, M or U corresponds to Infant, Middle Primary or Upper Primary, respectively. The middle letters for student teachers [Ni, Np, Udi, Udp, Ubi and Ubp] stand for the six student courses. These were the TCAE Infant Method, the TCAE Primary Method, the U of T Dip.Ed. Infant Method, the U of T Dip.Ed. Primary Method, the U of T B. Ed. Infant Method and U of T B. Ed. Primary Method courses, respectively. The letter A or B corresponds to the form of SATT. The larger the number within each teaching level for teachers the later the time of receipt. For student teachers the number within each of the six courses corresponds to the random order in which they were marked. In some cases minor liberties have been taken with spelling, punctuation and syntax.

#### Teacher Comment

##### Infant Teachers

- TIA001      Timing of testing probably not ideal (many teachers are busy with reports right now).
- TIA005      As an Infant teacher I felt that the test was directed towards the teachers' ability and not towards the teachers' ability to convey an understanding of spatial awareness to the age-level being taught. I have only read and used the Maths guidelines in relationship to Prep. and Grade 1 classes and therefore felt very limited in dealing with many of the questions, as a lot of the "terms" etc. I had not heard of since high school.
- TIA006      Need a lot of time which is something most people do not have. Consequently, I have completed the test in the evening while watching television - certainly not peak concentration time.
- TIA012      I have found these tests a real challenge of the knowledge I have of these concepts - some concepts I have not dealt with since High school maths. Feeling a little unconfident about some answers I have given. It is hoped that it is realised that teachers of infant children do not require the complex understanding of spatial relations that a high school teacher would need. I trust this consideration is made when analysing all test results.

- TIA013 As a concerned infant teacher (with Maths not exactly a strong point) I would like to see more ideas and suggestions put forward in covering spatial awareness in the grade 2-3 area. Young children are quick to pick up shapes from the environment etc. but where do you go from there until they are old enough to learn more formal geometry?
- TIA030 In some cases my memory completely fails me, as I have not needed to deal with particular topics since Grade 10 or earlier. E.g. a parabola or parabolic motion is something I would need to look up in order to complete the question. However, I have found this an interesting and hopefully worthwhile exercise.  
Since receiving this questionnaire I have gone onto accouchment leave, but I would have found this valuable had I still been teaching a class as many questions were relevant to ideas I tried to convey to my Prep/1 class and they made me think more deeply about their complexity in some cases. Good luck with your survey.
- TIA033 This test was very difficult, more so than the Monash Spatial Test. Although I learnt the concepts involved in these tests in high school I have forgotten a great deal as they do not arise in spatial teaching in infant mathematics.
- TIA036 Some questions have very badly executed drawings e.g. q. 8. The two tests together are a bit much for teachers even considering their good nature. Cut it down a bit.
- TIA038 Question 10 seems to be ambiguous.
- TIA039 I must apologize for the delay in returning the papers. Unfortunately when they arrived there were student teachers in our unit and my team teacher and I were attending Language, drama, science and swimming seminars after school. Because of this and our current trend in updating the language program, we were asked to show the developmental stages in our school. This was time consuming and we were constantly receiving visitors from local and mainland schools. My first priority is to the children of the unit so all other commitments must take second place. I did however, complete the mathematics paper. I must confess it caused me some concern as most of the problems are not applicable to the stage I teach (grades 1,2,3). We deal mainly with basic pure number. During applied areas, the environment is our greatest aid with

emphasis on estimation, the language and particularly the understanding. Language is of the utmost importance at this stage. I hope that the survey is successful and that I have helped a little with my meagre contribution.

- TIB012 In certain questions I was perplexed by mathematical terms (i.e. terminology) I had not dealt with before, and could therefore not participate in the problem.
- TIB017 I took 22 minutes to do the Monash Spatial Test and 40 minutes to do this test - in case this is of any interest to you. I enjoyed doing it - but found it hard to find the time - uninterrupted - in which to do it (family and school give very little chance - so I did it in bed!).
- TIB019 The first thing I am going to do after this is posted off is to introduce more Spatial Awareness activities into my classroom, and have a good peruse through my Guidelines!! I felt somewhat guilty - some of the language was very foreign.
- TIB023 Happy to cooperate but very time consuming.
- TIB024 I feel totally inadequate.
- TIB026 Term II is an inappropriate time to ask teachers to be involved in such a survey as it is such a busy time of the year.
- TIB028 A very thought-provoking exercise! I found questions 11 and 22 in the Monash Spatial Test to be the most challenging.
- TIB030 I have now decided I am totally inept when it comes to abstract thinking! I think I've got 2 left hands, and crossed eyes!
- TIB034 My apologies this is so late. I would be interested if your study is looking into spatial awareness problems and the slow learner/learning disabled and what possible solutions or suggestions you may come up with to help these children. (I probably need a programme for myself!!) I'm really talking about the child who has difficulties in things like starting to write on the L.H.S. of the page instead of the middle, writing words, e.g.  $c^a$  rather than  $cat$ , etc. I think these problems are more than just gross motor control.

TIB035 Many of the terms have not been utilized since High School, therefore they have lost their meaning. If I had taught grades in Upper Primary these terms would be constantly used.

TIB040 I found some of it very difficult but interesting. Had I had more time I feel I could have obtained a better result. However it would not have been a true test I suppose. If I had to do one again I would use the time differently. Perhaps you could advise me on where I could get some help in these areas as I am sure I need it.

#### Middle Primary Teachers

TMA001 I found I really had to think hard to answer many of these questions. I found myself relating back to maths lessons from high school level. I think in most cases and especially this that your answers come as a result from memory in past previous experiences. These experiences help in understanding spatial awareness you may be introducing to a class through activities but with a lot of research and preparation most teachers I feel should and could be capable in teaching in those areas. I agree there is a need for this type of study but do not spend too much time and money on it if possible.

TMA004 Speaking purely as a Primary school teacher, keeping in mind the range of spatial knowledge required to the end of Grade 6, I would have been interested to know if in future surveys of this kind you could insert in the "strictly confidential" questions on page 2 a space to show:

- a. Did you major in technical drawing at secondary school?
- b. Has your interest in your teaching career been in the Maths/science/technical subjects or in the Arts subjects? I feel that many teachers of my age in the Primary school who have a leaning to the Arts would have only bothered to retain enough information in questions like question 12, to be able to satisfy the questions a grade 6 pupil might ask. I mention this, in case your survey might indicate that a large % of teachers would not satisfactorily show a majority of correct answers in these tests. However, as your selection of candidates is a random one, I trust people like me are balanced by the number of teachers who would do extremely well.

- TMA005 Quest. 9 wording is poor. Does it mean cover all sides or 1 side? Quest. 10 - does this mean cut the triangle out?
- TMA009 I found this test mainly factual, whereas the Monash Test required far more thinking (logical and abstract thinking). I am not sure whether it was the way the quest. was presented (or my lack of knowledge) but I had difficulty in interpreting what was required in quest. 15.  
Question 9 in the Monash test didn't give accurate choices. I enjoyed participating and I especially enjoyed the Monash Test.
- TMB002 It just made me realise how readily answers come to you if you use the particular concept required frequently enough.
- TMB003 I appreciated the chance to complete this test, mainly to make me realise how much I had forgotten and how many areas of spatial awareness are overlooked in the curriculum.
- TMB004 I will not [be a typical member of your sample in] my secondary education and TCAE training due to my first year training at XXXX. 1st year training at XXXX dealt in some depth in this area as part of the compulsory Mathematics year 1 course, where we had to have an 80% proficiency in the areas studied. Hence the knowledge which I have not come into contact with during any other part of my education both secondary and tertiary. Further studies have only been for relaxation. I enjoyed the test as a whole as a stimulating exercise.
- TMB005 As I haven't done Maths as a subject for 8 years I find my knowledge on specific things is not as good as it was in Year 12. Also, I teach Grade 4, and therefore have no need for regular use of some of the concepts and thus tend to forget things that are not needed.
- TMB008 Some of these questions rely on knowledge of definitions or other properties, e.g. translation, tessellation, a triangle has 180 degrees, etc., rather than mere spatial awareness. This may bias the result toward people who learn such definitions (or in the case of teachers - people who teach them).
- TMB012 Please, in future, allow us busy people more time to complete the test - a week is not enough! I simply do not have the 1-2 hours to spare for tests such as these on top of all the school preparation that has to be done through the week. Question 15 in the green book is badly expressed and full of

ambiguity. I spent a long time trying to sort out what you meant. Was it a trick question? Were we meant to paint the underside of the top block as well? (This block was merely 'joined'.) In your initial letter you wrote that 'tests have been trialled with the staffs of a number of schools...' Please do not use this ugly word 'trialled'. To my knowledge it is not an acceptable verb in the English language. What is wrong with good old word 'tested', viz: 'The staffs of a number of schools have taken these tests.' As a music teacher I see little values in tests such as these.

#### Upper Primary Teachers

- TUA002    Quest. 20 is ambiguous or something or other. Quest. 5 and 6 are difficult to understand. Just exactly what is required? What does solid numbers mean - I thought it referred to quest 4. After looking closer I noticed at the top of the page that they were. Perhaps for dills like me that ought to be incorporated into quest. 5 and 6.
- TUA005    Quest. 13 in the Monash Spatial test I tried various possibilities but finally guessed the answer on the basis of combinations used re. the original triangle and square. I would be pleased to know the solution and the method involved.
- TUA009    If possible would you mind sending a copy or several copies of each test or similar samples as shown in this test with correct answers which I may be able to use with my class. I am sure they would find many of these types of questions a worthwhile challenge.
- TUA010    Timing of this during the writing of reports - inappropriate.
- TUA014    I found quest. 27 the most difficult and most time consuming. Quest. 34 proved the next most time consuming. In quest. 13 I endeavoured to tessellate the hexagon. In nature the bees make them. However I found my drawing skills not up to task, so chose an easier square pattern. I found I did the "teaching test" much quicker than the Monash Spatial Test.
- TUA019    Some of the items tested subject matter that related to my school maths when I was a pupil, but most subjects only became part of my maths knowledge and understanding while I was a classroom teacher. I did have to guess a couple of answers, quest. 29 and 35, but feel reasonably confident

about all other answers except quest. 4 and 12.

- TUA022 Found it testing or I am only a Principal so what can you expect.
- TUB001 Good stuff!!
- TUB002 I don't think we should truly consider the level of maths studied at High School - after all it is 36 years since I finished High School and we really didn't learn about tessellations, transformations or any of the interesting things we teach today. Anything I know in Spatial Knowledge I have learned through work shops, seminars and reading. Although I teach Grade 6, I trained as an Infant teacher, then worked years in Infant or lower primary grades.
- TUB003 Question 7 invalid - debate the issue of thick and thin circles - circle is a plane shape, it has no thickness.
- TUB007 Many items made me stop and think - not because I have been teaching my class these things but am I being too abstract in my approach to this subject? Do I expect too much? I hope not as I find this area a most enjoyable part of maths.
- TUB018 Question 34 - slightly ambiguous. Does 'nature' refer to laws of nature?
- TUB023 Puzzled over q. 34 for a long time. Couldn't think of much in nature. Would like to know correct answers.
- TUB029 Due to heavy work committments I have been unable to devote the time necessary for the successful completion of the paper until 15/7/82. I apologise for the inconvenience.

#### Student Teacher Comment

#### TCAE Infant Method

- SNiA011 Some questions were a little difficult to understand what it was exactly one was being requested to do. In this type of situation it is only the mathematics which should be being tested - not comprehension. There should be one objective only!
- SNiA013 The questions were not explicit enough and far too ambiguous. The content covered by the questions was far too advanced for Grade 10 level II Maths



graduates. And if there were people here who did have ample knowledge then it would be obsolete for this Infant course. In other words we know enough about Maths to educate young children - so what is all the panic about?

- SNiA017 I hope some of those questions were poorly worded intentionally.
- SNiB001 Question 9 (SATT) is not very easy to understand. The word 'another' is used and this seems to indicate that another cube has already been made. This is not the case, so it becomes rather confusing.
- SNiB007 I enjoyed doing the test.
- SNiB009 In q. 32 on shadows, 2 answers could be obtained by putting angle on the light source, but in the others the light is on a plane with the cube. Therefore E is the most correct although it is also possible for D if it is assumed the light source is at a fixed angle.
- SNiB010 The test made it clear to me the areas where I am deficient. However before teaching a subject or introducing a new concept the teacher would make herself more aware of the terminology and processes involved.
- SNiB011 Reference to some particular activities e.g. tessellations, would depend very much on what particular schools you had been in, as not all schools would have these activities.
- SNiB012 My godfather! I haven't even heard of half the terms that we were expected to comment about, e.g. parabolic motion could have been an alcoholic paramedic for all I know!

U of T Dip.Ed. Infant Method

- SUdiB003 1) It would be good to have some instructions as to whether one should attempt to guess at an answer, if it is not known.
- 2) Similarly the logic behind subject choices in answering would be useful to know. E.g. I know I surprised myself by some of the answers I gave. Also need instruction to know whether we can draw or not.
- 3) Some of the instructions could have been more clearly and easily worded, e.g. q. 26. Does this mean the shapes are able to overlap? One presumes not. Generally, however, I thought the questions

K10

were well worded as compared to more traditional maths tests I have done.

SUdiB004 Wide range.

SUdiB008 It was unfortunate that both tests had to be given together. The attention span required was too long.

SUdiB009 q. 34 - difficult to think of examples.

SUdiB011 In question 9 I would like to write 26 but it's not listed. I guess I'm wrong.

U of T B. Ed. Infant Method

SUbiA003 Very interesting.

SUbiA005 I do not see what spatial awareness has to do with formal mathematical terms. I hope I might have been able to answer some of the questions correctly if I had known the meaning of the terms mentioned.

SUbiA013 Some questions are quite ambiguous.

SUbiA016 Cannot understand quest. 20. Do the squares overlap each other or the circle or both? If they can overlap the circle the answer is (d).

SUbiA020 In the first paper, I could not think of the pattern used at all. Some questions were really easy, others hard as I forgot things learnt in the past. In quest. 13 I know at Port Arthur there are tessellated pavements but I do not know what it is about them which makes them tessellated. Hence, I do not know how a plane can be made to tessellate as in quest. 25. Not really sure of the meaning of rotation in the cases here.

SUbiA026 Do not understand terminology of some questions.

SUbiA027 Several of the words, e.g. parabola, I had never seen before.

SUbiB002 Was I meant to know what a parabola was? If you haven't already guessed I didn't!

SUbiB007 A real brain wrecker/racker. Some questions assume certain unstated things, e.g. q. 16. The clock is going for a whole week and that it is going "properly".

SUbiB008 Would be terrific test for students doing Manual Arts.

- SUBiB022 May not recognise the names of certain concepts, e.g. isosceles, but may really know what it is.
- SUBiB025 Too long with both tests being performed one after another in a stuffy room. Consequently lost concentration.
- SUBiB027 I have never heard of a parabola or parabolic motion and I can't remember what a tessellation is.

TCAE Primary Method

- SNpA007 Need in spatial awareness problems to be much more related to real life situations, e.g. q. 29, in rescue work.
- SNpA009 Felt lost at times with abstract rather than concrete notions.
- SNpB002 The test (SATT) relied quite heavily on the individual's ability to visualize pictures in his mind. This is especially true for questions such as 23, 26, 27 and 30.
- SNpB004 Little spatial awareness work is being done in schools and it is not encouraged a great deal.
- SNpB005 Interesting.
- SNpB007 Questions such as 35 do not really test spatial awareness but rather the retention of formulae.
- SNpB008 Some of the examples are excellent - wouldn't mind getting a hold of this test. The questions on the type of movement I would be a bit dubious about, e.g. 22 and 34. Certainly primary school children wouldn't need to be concerned with them and I'm not just saying that because I've forgotten what a parabola is! Comparison questions are very good and also the turning around idea. I don't think I want to know my score though!

U of T Dip.Ed. Primary Method

- SUdpA002 A lot more definition of terms would be appreciated.
- SUdpA003 I do not know what a tessellation is - should there be more than one question on referential background related to one question?
- SUdpA006 I have obviously missed the explanation of some words.

SUdpA009 You definitely need a geometrical background or "crash course" revision with a lot of the terminology.

SUdpA012 Quest. like 4, 6, 12 rely on information learned in early high school or primary school. I cannot remember these sorts of things. Also, quest. 29 - you needed to remember where elevation was measured from. Further, the no. of choices tends to be confusing. Quest. 35 - need to remember which is reflex.

SUdpB006 9 and 27 are badly worded.

SUdpB007 I couldn't do it, because I didn't understand a lot of the terminology (also, anything to do with maths makes my mind go blank).

SUdpB009 Qq. 10 and 25 (especially) helped considerably with q. 13.

SUdpB010 Can't understand terms e.g. tessellation.

SUdpB011 No idea what tessellation is. Can't remember parabola. Primary ed. done in England - if it's useful to you.

SUdpB012 Well set out, and easily enough understood directions.

#### U of T B. Ed. Primary Method

SUbpA004 I found it difficult even to attempt to answer when I did not know the answer to three of the questions. It would have been useless to ask because that would have required a definition which we were told could not be given.

SUbpA006 Caught me out on some of these Kevin, e.g. not sure what a reflex angle is.

SUbpA008 Some questions are inhibited in their spatial awareness quality because of definition understanding, e.g. quest. 34.

SUbpA009 Give tests in separate sessions.

SUbpA012 Interesting problems. Would be an advantage for teachers to have copies of problems and answers for one's own learning as well as the children's. An interesting and enlightening task.

SUbpA016 This exam is really interesting. I would like to do more tests like this.

SUbpB006 q. 15 - comment in parentheses only confuses.

SUbpB008 q. 29 was imprecise as I didn't know if I was the man on the boat or on the cliff!

- SUbpB011 q. 1. - too general. Were they walking/running etc?  
q. 23 - too easy if the reader realizes that the paper can be seen through.
- SUbpB012 Some questions were very easy. Others were very hard. An odd mixture.
- SUbpB016 For just a moment I thought I was sitting a H.S.C MATHS EXAM. Please excuse my remarks made during the exam. This showed me that my knowledge of spatial awareness needs revision!! Thanks.

Appendix L

Test, Subtest and Item Data from  
SATT Form A and Form B

Table L.1

The Form of SATT having the Larger Proportion of Correct Responses for Teachers - the Common Questions

Question Number.	Form Containing the Higher Proportion of Correct Responses.	Corrected Value.
2	A	.00
3	A	.00
7	B	.76
12	A	.82
13	A	1.10
17	A	.00
21	A	.09
22	B	.10
25	A	1.50
29	B	.00
34	B	2.39
36	B	.39

X<sup>2</sup>

Table L.2

The Form of SATT having the Larger Proportion of Correct Responses for Teachers - the non-Common Questions

Question Number.	Form Containing the Higher Proportion of Correct Responses.	Corrected $\chi^2$ Value.
1	A	.91
4	B	73.87 ***
5	B	44.21 ***
6	B	47.74 ***
8	B	.01
9	A	12.10 ***
10	A	19.34 ***
11	B	2.27
14	B	1.57
15	A	1.78
16	A	32.99 ***
18	B	.68
19	A	35.75 ***
20	B	20.76 ***
23	A	.00
24	A	4.53 *
26	A	.26
27	B	.63
28	B	.75
30	B	.01
31	A	7.22 **
32	A	12.37 ***
33	B	1.02
35	B	40.34 ***

\*  $\underline{p} < .05$

\*\*  $\underline{p} < .01$

\*\*\*  $\underline{p} < .001$



Table L.3

Distribution of the Significantly Different Questions for Teachers by Form and Subtest

	Subtest			Sum
	Infant	Middle Primary	Upper Primary	
Form A	2	3	2	7
Form B	3	1	1	5
Sum	5	4	3	12

Table L.4

## Percentage of Infant Teachers Correct on Infant Subtest Questions

Question Number	Form A (N=40)	Form B (N=42)	Common Questions (N=82)
1	95.0	92.9	
2	100.0	100.0	100.0
3	75.0	78.6	76.8
4	35.0	100.0	
5	47.5	95.2	
6	47.5	95.2	
7	40.0	40.5	40.2
8	97.5	97.6	
9	92.5	64.3	
10	75.0	40.5	
11	97.5	95.2	
12	30.0	23.8	26.8

Table L.5

Percentage of Middle Primary Teachers Correct on  
Middle Primary Questions

Question Number	Form A (N=17)	Form B (N=17)	Common Questions (N=34)
13	70.6	64.7	67.6
14	52.9	64.7	
15	88.2	82.4	
16	100.0	70.6	
17	76.5	70.6	73.5
18	100.0	94.1	
19	100.0	76.5	
20	64.7	100.0	
21	94.1	94.1	94.1
22	52.9	82.4	67.6
23	94.1	100.0	
24	88.2	64.7	

Table L.6

Percentage of Upper Primary Teachers Correct on  
Upper Primary Questions

Question Number	Form A (N=22)	Form B (N=30)	Common Questions (N=52)
25	45.5	50	48.1
26	100.0	86.7	
27	54.5	73.3	
28	72.7	86.7	
29	95.5	93.3	94.2
30	90.8	100.0	
31	77.3	46.7	
32	100.0	73.3	
33	100.0	100.0	
34	45.5	46.7	46.2
35	45.5	93.3	
36	63.6	90.0	78.8

Table L.7

The Form of SATT having the Larger Proportion of Correct Responses for Student Teachers - the Common Questions

Question Number	Form Containing the Higher Proportion of Correct Responses	Corrected value
2	A = B	-
3	B	.65
7	A	.38
12	A	.00
13	B	.14
17	A	.54
21	A	.60
22	A	1.16
25	B	1.46
29	B	1.99
34	B	.75
36	A	1.20

Table L.8

The Form of SATT having the Larger Proportion of Current Responses for Student Teachers - the non-Common Questions

Question Number	Form Containing the Higher Proportion of Correct Responses	Corrected value
1	A	3.47
4	B	118.86 ***
5	B	22.66 ***
6	B	45.80 ***
8	B	1.46
9	A	.00
10	B	.04
11	B	.40
14	B	9.59 **
15	A	.00
16	A	76.05 ***
18	B	.36
19	A	98.04 ***
20	B	54.49 ***
23	A	.02
24	A	14.70 ***
26	B	3.40
27	A	1.83
28	A	.02
30	A	.00
31	A	10.81 **
32	A	2.07
33	B	.24
35	B	77.00 ***

\*\*  $p < .01$

\*\*\*  $p < .001$

Table L.9

Distribution of the Significantly Different Questions  
for Student Teachers by Form and Subtest

	<u>Subtest</u>			Sum
	Infant	Middle Primary	Upper Primary	
Form A	-	3	1	4
Form B	3	2	1	6
Sum	3	5	2	10

Table L.10

Percentage of Infant-Student Teachers Correct on Infant.  
Subtest Questions

Question Number	Form A (N = 56)	Form B (N = 56)	Common Questions (N = 112)
1	94.6	83.9	
2	100.0	100.0	100.0
3	73.2	80.4	76.8
4	12.5	91.1	
5	42.9	75.0	
6	51.8	92.9	
7	39.3	30.4	34.8
8	87.5	94.6	
9	64.3	48.2	
10	50.0	58.9	
11	89.3	94.6	
12	10.7	10.7	10.7



Table L.11

Percentage of Primary Student Teachers Correct on Primary Questions

Question Number	Form A (N = 39)	Form B (N = 42)	Common Questions (N = 81)
13	56.4	66.7	61.7
14	33.3	64.3	
15	71.8	71.4	
16	97.4	47.6	
17	71.8	59.5	65.4
18	92.3	100.0	
19	97.4	26.2	
20	61.5	100.0	
21	89.7	83.3	86.4
22	76.9	76.2	76.5
23	89.7	83.3	
24	71.8	50.0	
25	23.1	47.6	35.8
26	59.0	73.8	
27	66.7	40.5	
28	64.1	61.9	
29	71.8	81.0	76.5
30	94.9	95.2	
31	43.6	14.3	
32	69.2	69.0	
33	79.5	92.9	
34	30.8	38.1	34.6
35	7.7	88.1	
36	30.8	31.0	30.9

Appendix M

KR-20 SATT Test and Subtest  
Reliability Coefficients

## Appendix M

Table M.1

The KR-20 Test and Subtest Coefficients for Teachers on SATT Form A

Sample or Subsample	N	Test or Subtest	No. of items possible	No. of items actual	K.R.=20
All teachers	85	Form A	36	35	.7554
All teachers	85	Infant subtest	12	11	.5359
Infant subsample	40	Infant subtest	12	11	.6055
All teachers	85	Middle Primary subtest	12	12	.5752
Middle Primary subsample	17	Middle Primary subtest	12	19	.6864
All teachers	85	Upper Primary subtest	12	12	.4509
Upper Primary subsample	22	Upper Primary subtest	12	19	.3753

Table M.2

The KR-20 Test and Subtest Coefficients for Teachers on SATT Form B

Sample or Subsample	N	Test or Subtest	No. of items possible	No. of items actual	K.R.-20
All teachers	93	Form B	36	36	.6838
All teachers	93	Infant subtest	12	12	.2164
Infant subsample	42	Infant subtest	12	10	-.0522 <sup>+</sup>
All teachers	93	Middle Primary subtest	12	12	.4909
Middle Primary subsample	17	Middle Primary subtest	12	10	.4477
All teachers	93	Upper Primary subtest	12	12	.5076
Upper Primary subsample	30	Upper Primary subtest	12	10	.3211

<sup>+</sup> This anomalous result could indicate that this Infant subtest should be closely looked at before its use again in another survey.

Table M.3

The KR-20 Test and Subtest Coefficients for Student Teachers on SATT Form A.

Sample or subsample	N	Test or Subtest	No. of items possible	No. of items actual	K.R.-20
All student teachers	95	Form A	36	35	.7680
All student teachers	95	Infant subtest	12	11	.5895
Infant subsample	56	Infant subtest	12	11	.5939
All student teachers	95	Primary subtest	24	24	.6469
Primary subsample	39	Primary subtest	24	24	.7067

Table M.4

The KR-20 Test and Subtest Coefficients for Student Teachers on  
SATT Form B

Sample or subsample	N	Test or Subtest	No. of items possible	No. of items actual	K.R.-20
All student teachers	98	Form A	36	34	.7792
All student teachers	98	Infant subtest	12	11	.4271
Infant subsample	56	Infant subtest	12	11	.4295
All student teachers	98	Primary subtest	24	23	.7379
Primary subsample	42	Primary subtest	24	22	.7383